VOL. XI JANUARY 1957 NO. 1

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Bryant and Gressitt — *Chrysomelidae of Fiji* ● Dawson — *Annotated List of Marine Algae from Eniwetok* ● NOTES: Strasburg and Hiatt — *Sexual Dimorphism in* Gomphosus ● News Notes

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(Continued on inside back cover)

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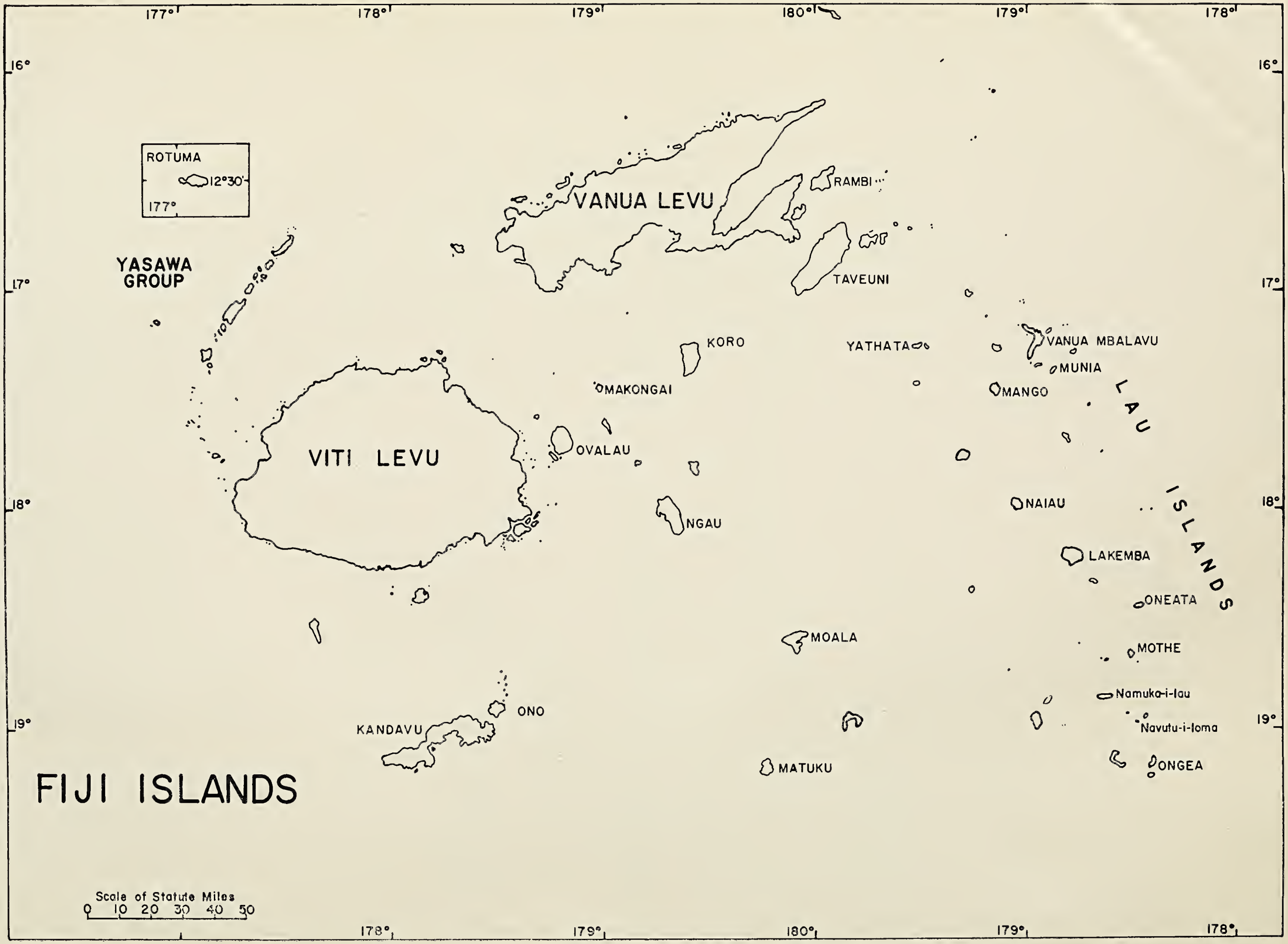
FIJI ISLANDS
ROTUMA
12°30'
177°
YASAWA GROUP
VANUA LEVU
VITI LEVU
RAMBI
TAVEUNI
KORO
MAKONGAI
OVALAU
NGAU
YATHATA
VANUA MBALAVU
MUNIA
MANGO
LAU ISLANDS
NAIAU
LAKEMBA
ONEATA
MOALA
MOTHE
Namuka-i-lau
Navutu-i-loma
ONGEA
MATUKU
ONO
KANDAVU
Scale of Statute Miles
0 10 20 30 40 50
177°
178°
179°
180°
16°
17°
18°
19°

Chrysomelidae of Fiji (Coleoptera)[1]

G. E. Bryant and J. L. Gressitt[2]

This report is based primarily on the extensive collection made by E. C. Zimmerman in 1938 as a member of the Bishop Museum's Henry G. Lapham Fijian Expedition. Additional material was taken by J. M. Valentine in 1937, N. L. H. Krauss in 1941, 1950, 1951, and 1955, E. H. Bryan, Jr. in 1924, and J. L. Gressitt in 1952 and 1955. A few other specimens were taken by Albert Koebele, J. F. Illingworth, H. S. Ladd, W. Greenwood, W. H. Ford, C. M. Cooke, Jr., Otto Degener, Yoshio Kondo, R. W. Paine, R. A. Lever, and B. A. O'Connor. A total of about 3,500 specimens from Fiji was available for study.

Much of the older material was originally sent to the late Dr. S. Maulik, who found little time to devote to it before his death. The senior author then undertook the study at the request of E. C. Zimmerman, and identified much of the material, preparing descriptions of some new species and notes on others. The junior author was asked to go over the unidentified material and newer collections, and has added to the keys and descriptions. He has also made a special effort to obtain records with host-plant data during a visit to Vanua Levu in 1955. Because the work was largely done separately, the new species are individually credited to the describers. We are much indebted to Mr. Zimmerman for time spent in sorting the material, and in helping to compile the list of previously recorded species.

The host plants were kindly identified by A. C. Smith. Some host data and other information was supplied by B. A. O'Connor. The drawings of adults were made partly by the senior author, and partly by Dorothy Rainwater. The drawings of the genitalia were prepared by the junior author.

All types (with one exception) are deposited in Bishop Museum (Bishop), with paratypes in the British Museum of Natural History (BM). Some paratypes are also deposited in the United States National Museum (US), the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra, and the California Academy of Sciences (CAS).

There are two systems of romanization of Fijian place names. The long-used system in Fiji utilizes "c" for the "th" sound, and "q" or "g" for the "ng" sounds. Instead of the former system, the actual phonetic spellings are used in this paper. When the old spellings occur on specimen labels, they are inserted in the text in parentheses following the phonetic spellings.

SPECIATION AND ZOOGEOGRAPHY

This very interesting collection, a tribute to Mr. Zimmerman's interest, has proven to be a most difficult one on which to report.

[1] This research was aided by a John Simon Guggenheim Memorial Foundation Fellowship to the junior author, 1955–1956. Manuscript received December 30, 1955.

[2] Commonwealth Institute of Entomology, London, and Bernice P. Bishop Museum, Honolulu, respectively.

Generic and specific boundaries have not been easy to determine, and, after repeated study, some specimens must still be left unidentified and others given questionable generic placement. Furthermore, the major part of the material belongs to the subfamily Eumolpinae, which is known for the difficulty of tribal and generic placement of its members. It may be of interest to quote Maulik's statement [1929: 191]: "The study of the Eumolpinae of the present collection lends support to an idea which suggested itself to me when I was studying other island faunas, such as that of the Seychelles. In that case also I was confronted with the same difficulty of judging the limits of a species which showed structural variations. The idea may be formulated thus: in island faunas species tend to become more plastic than in continental faunas." This statement would appear to apply very well also to the chrysomelid fauna of Fiji, and particularly to that of the subfamily Eumolpinae.

Fiji has a rather rich insect fauna, possessing many genera not found farther east in the Pacific. Also, the endemicity is rather high. Only six of the fifteen Asiatic subfamilies of Chrysomelidae are represented in Fiji, whereas twice as many, or more, are represented in New Guinea. Thus it would appear safe to say, from consideration of this family of beetles, that Fiji represents an oceanic island group, or a relic continental group, which lost much of its original fauna through partial submersion, vulcanism, or tectonic activity.

Fiji possesses many old metamorphic and plutonic rocks, suggesting that it was part of an ancient Melanesian continent (Ladd, 1934: 49). On the other hand, Mayr (1941: 191–195) and Myers (1953: 19–27) have shown that the vertebrate fauna indicates that Fiji is oceanic rather than continental. The junior author feels that if Fiji were continental in the full sense, then more subfamilies, tribes, and genera of Chrysomelidae should be represented (see Gressitt, 1956: 14). The situation in this family appears to differ from that in the Tenebrionidae as discussed by Kaszab (1955: 430), who concluded that the Fijian fauna was continental.

The Fijian chrysomelid fauna is characterized by a fairly small number of genera (35), many of which have developed a considerable number of species. There are four genera with species thought to be all introduced, or of doubtful generic placement. The remaining 31 genera possess an average of 4.3 species per genus in Fiji. Actually the ratio is still greater, as a number of species represented by uniques are left unnamed. Seven genera have over six species, five genera have over eight species, and three have over ten species. There are three endemic genera, besides some which may need naming.

The distribution of the 32 non-endemic genera, including those with introduced species, is as follows:

	NUMBER OF GENERA
Fiji and Samoa only	2
Fiji, Samoa, New Hebrides	1
Fiji and New Hebrides	2
Fiji and New Zealand	2
Fiji and Australia	2
Fiji and Papuan Subregion	2
Fiji and Solomons (one also in New Hebrides and Samoa)	2
Fiji and Philippines	1
Fiji and Africa (also Madagascar, New Caledonia, and perhaps Australia)	1
Fiji and Oriental Region (some occurring also in New Guinea or intermediate islands)	9
Cosmopolitan	8

Hence the relationships appear to be with Southeast Asia, through New Guinea, much more than with the Australian region. Nine of the twelve chrysomelid genera in Samoa are also found in Fiji. Six of the 17 Micronesian genera also occur in Fiji.

Of the 137 species or subspecies listed in this work, 127 appear to be endemic to Fiji.

The following five species appear to be introduced to Fiji:

Aulacophora nigrivestis (Boisduval)
Aulacophora quadrimaculata (Fabricius)
Aulacophora similis (Olivier)
Plesistia brunnea Maulik
Altica corusca Erichson

Possibly *Plesistia brunnea* evolved in Fiji, and was introduced to Samoa. It is also possible that *Promecotheca caeruleipennis* Blanchard (*reichii* Baly) might have been introduced from Tonga to Fiji, or vice versa. Taylor (1937) considered it indigenous to Fiji.

Thus, except for the preceding two species and *Vitibia formosa* (Baly), *Phyllotreta blackburni* Bryant, and the genus *Eurydemus*, all of the non-introduced species in Fiji appear to be endemic. Seventy-one kinds are described in this paper as new, and, of these, six are new subspecies. Two new genera are proposed.

Local endemicity within Fiji appears to be clearly developed. The species from Kandavu, Moala, and Lau are in many cases different from those of the main islands, and different from each other. Many of the species from Ovalau appear to be the same as those on Viti Levu, and a similar relationship appears to exist between those of Taveuni and Vanua Levu. As to Viti Levu and Vanua Levu, there appear to be both species in common and sibling species or separate races on the two islands. A number of species listed as common to the two main islands may actually consist of weak separate races. Again, the problem of determining limits of species renders most difficult the decisions on mono-insular endemicity.

TABLE 1
DISTRIBUTION OF FIJIAN CHRYSOMELIDAE

	Viti Levu	Ovalau	Vanua Levu	Taveuni	Central Fiji	Lau I.	Kandavu	OTHER LOCALITIES
CRYPTOCEPHALINAE								
1. *Coenobius geniostomae* Gr., n. sp.			×					
2. *C. m. marginipennis* Bry.......	×		×	×				
3. *C. m. lauensis* Gr., n. subsp....						×	×	
4. *C. producticollis* Gr., n. sp.....	×	×						
5. *C. zimmermani* Gr., n. sp......		×						
6. *Ditropidus punctulatus* Chapuis.						×		
7. *D. tibialis* Chapuis..........	?							
8. *Pycnophthalma cuprea* Bry.....	×							
9. *P. aureopilosus* (Bry.).........	×							
10. *P. apicale* Bry., n. sp.........	×							
11. *P. leveri* Bry................	×							
12. *Loxopleurus costipennis* Bry.....	×					×		
13. *L. leveri* Bry................						×		
14. *L. ruficollis* Bry., n. sp........	×					×		
15. *L. vitiensis* Bry..............	×							
16. *L. rotumanus* Gr., n. sp.......								Rotuma
17. *Cryptocephalus fraterculus* Chapuis................	×							
EUMOLPINAE								
18. *Lindinia glabrata* Bry., n. sp. .	×							
19. *Rhyparida dispar* Bry.........	×		×					
20. *R. trapezicollis* Fairmaire......	×	×	×					
21. *R. oblonga* Bry., n. sp........	×							
22. *R. fijiensis* Gr., n. sp..........	×							

TABLE 1 (*continued*)
DISTRIBUTION OF FIJIAN CHRYSOMELIDAE

CRYPTOCEPHALINAE	Viti Levu	Ovalau	Vanua Levu	Taveuni	Central Fiji	Lau I.	Kandavu	OTHER LOCALITIES
23. *R. laddi* Gr., n. sp.	×							
24. *R. luteola* Fairm.	×		×					
25. *R. vermiculata* Gr., n. sp.						×		
26. *R. kandavu* Gr., n. sp.							×	
27. *R. strigosa* (Bry.)	×							
28. *R. bryani* Gr., n. sp.						×		
29. *Labasa scutellaris* Bry.	×		×					
30. *Vitibia formosa* (Baly)	×		×				×	New Hebrides
31. *V. rufoviolacea* Fairm.	×							
32. *V. montana* Gr., n. sp.	×							
33. *V. greenwoodi* (Bry.)	×	×						
34. *V. striatipennis* Bry., n. sp.	×							
35. *V. vitiensis* (Bry.)	×	×		×	×	×		
36. *V. melochiae* Gr., n. sp.	×		×				×	
37. *V. duplicata* Gr., n. sp.	×							
38. *V. rufilabris* Bry., n. sp.	×							
39. *V. obscura obscura* Gr., n. sp.	×							
40. *V. o. submetallica* Gr., n. subsp.			×					
41. *V. bryanti* Gr., n. name	×							
42. *V. testacea* Gr., n. sp.	×	×						
43. *V. virida* Gr., n. sp.	×							
44. *V. dimorpha* Gr., n. sp.	×							
45. *V. pallipes* Bry., n. sp.	×							
46. *Stygnobia evansi* (Bry.), n. comb.				×				
47. *S. oconnori* Gr., n. sp.	×	×	×			×		
48. *S. albiseta* Gr., n. sp.					×			
49. *S. metallica* Bry.	×	×	×	×				
50. *S. elliptica* Gr., n. sp.	×							
51. *S. nandarivatu* Gr., n. sp.	×							
52. *S. leveri* (Bry.), n. comb.	×	×	×	×				
53. *S. ovalaua* Gr., n. sp.	×	×			×			
54. *Epinodostoma alocasiae* Gr., n. sp.			×					
55. *E. elongata* Bry., n. sp.	×							
56. *Eurydemus grandis* (Baly)		×	×				×	New Caledonia
57. *E. insignis* Chapuis				×				Australia
58. *Stethotes rufipes* Bry.	×							
59. *S. setosa* Gr., n. sp.	×							
60. *Parademotina aureotincta* Gr., n. sp.	×							
61. *Demotina pallipes* Bry., n. sp.						×		
62. *D. glochidiona* Gr., n. sp.			×					
63. *D. fulva* Bry.	×		×			×		
64. *D. metallica* Bry., n. name	×	×	×					
65. *D. vitiensis* Bry.	×	×	×			×		
66. *D. bifasciata* Bry., n. sp.	×							
67. *D. albonotata* Bry.	×	×			×			
68. *D. evansi* Bry.			×	×				
69. *D. obscurata* Bry.	×		×	×				
70. *D. dissimilis* Bry.	×	×	×	×	×	×		
71. *D. irregularis* Bry., n. sp.	×							
72. *D. striata* Bry., n. sp.	×	×						

	Viti Levu	Ovalau	Vanua Levu	Taveuni	Central Fiji	Lau I.	Kandavu	OTHER LOCALITIES
73. *D. pubescens* Gr., n. sp.					×			
74. *D. veitchi* Bry.	×	×	×					
75. *D. fragilis* Gr., n. sp.	×	×						
76. *D. nodosa* Bry., n. sp.	×							
77. *D. rugosata* Gr., n. sp.	×	×	×					
78. *D. cylindricollis* Gr., n. sp.	×							
79. *Damelia marshalli* Clark	×							
80. *D. verrucosa* Bry., n. sp.	×	×						
81. *D. rugosa* Bry., n. sp.	×							
82. *Eucolaspis castanea* Bry., n. sp.	×							
83. *E. saltator* Gr., n. sp.			×					
84. *Colaspoides brunnea* Bry., n. sp.	×	×						
85. *C. confusa* Gr., n. sp.	×							
86. *C. vitiensis* Bry.	×		×		×			
CHRYSOMELINAE								
87. *Plagiodera violaceipennis* Bry.	×	×	×			×		
GALERUCINAE								
88. *Aulacophora nigrivestis* (Boisd.)	×							Australia
89. *A. quadrimaculata* (Fabr.)	×	×				×	×	Yasawa, Samoa, Melanesia, Queensland, W. Micronesia
90. *A. similis* (Oliv.)	×	×	×	×	×	×	×	S. E. Asia, Melanesia, W. Micronesia, Samoa
91. *Malacotheria funerea* Fairm.	×							
92. *M. strigiscutata* Fairm.	×	×						
93. *M. lateritia* Fairm.	×	×	×					
94. *Plesistia brunnea* Maulik	×							Samoa
95. *Haplosomoides binotata* Bry., n. sp.	×	×						
96. *Khasia nigra* Bry.	×	×						
97. *K. nitida* Bry., n. sp.	×							
98. *K. r. rugosa* Bry., n. sp.	×	×						
99. *K. r. callosa* Gr., n. subsp.			×					
100. *Cerophysa vitiensis* Bry.	×							
101. *Monolepta* (*Metrioidea*) *s. signatipennis* (Fairm.)	×	×						
102. *M.* (*M.*) *s. lauana* Gr., n. subsp.						×		
103. *M.* (*M.*) *s. kandavuna* Gr., n. subsp.							×	
104. *M.* (*M.*) *moala* Gr., n. sp.					×			
105. *M.* (*M.*) *zimmermani* Bry., n. n.	×	×						
106. *M.* (*M.*) *vitiensis* Bry.			×					
ALTICINAE								
107. *Phyllotreta blackburni* Bry.	×							New Hebrides
108. *Aphthona veitchi* Bry.	×	×						
109. *A. greenwoodi* Bry.	×							
110. *A. lamia* Gr., n. sp.	×							
111. *A. senetiki* Gr., n. sp.			×					
112. *Altica corusca* Erichson	×	×	×			×		Tasmania, New Hebrides

TABLE 1 (*continued*)
DISTRIBUTION OF FIJIAN CHRYSOMELIDAE

	Viti Levu	Ovalau	Vanua Levu	Taveuni	Central Fiji	Lau I.	Kandavu	OTHER LOCALITIES
113. *Crepidodera oceanica* Gr., n. sp.	×							
114. *C. elongata* Gr., n. sp.		×						
115. *C. evansi* Bry.				×				
116. *C. fijiensis* Csiki	×		×					
117. *C. kraussi* Gr., n. sp.	×							
118. *C. rotunda* Gr., n. sp.	×							
119. *Psylliodes simmondsi* Bry.	×							
120. *P. vitiensis* Bry.	×							
121. *Alema leveri* Bry.				×				
122. *A. nigra* Bry.	×							
123. *Manobia metallica* Bry.	×							
124. *M. levicollis* Gr., n. sp.	×							
125. *M. obtusicollis* Gr., n. sp.	×							
126. *M. producticollis* Gr., n. sp.	×							
127. *Nesohaltica brunnea* Bry., n. sp.	×							
128. *N. lauensis* Gr., n. sp.						×		
129. *N. vitiensis* Bry.		×	×					
130. *Febra venusta* Clark	×	×	×					
131. *F. insularis* Bry.	×							
132. *F. varioloidea* Fairm.		×						
133. *F. rubra* Gr., n. sp.	×							
134. *F. n. nigroornata* Bry., n. sp.	×							
135. *F. n. vanuana* Gr., n. subsp.			×					
HISPINAE								
136. *Promecotheca caeruleipennis* Blanchard	×	×	×	×	×	×	×	Yasawa, Samoa, Tonga
137. *P. bicolor* Maulik	×		×					

KEY TO SUBFAMILIES OF *CHRYSOMELIDAE* FOUND IN FIJI

1. Head normal, with vertex not projecting and with mouth directed forward or downward 2

   Head with vertex projecting strongly forward and mouth directed posteriorly below .... **Hispinae**

2(1). Antennae closely inserted on front of head; elytra not very rigid 3

   Antennae not closely inserted, separated by frons or vertex; elytra generally somewhat rigid 4

3(2). Posterior femur not greatly enlarged .... **Galerucinae**

   Posterior femur strongly swollen, adapted for jumping .... **Alticinae**

4(2). Middle three abdominal sternites not constricted; form of body more or less ovate or rounded, often strongly convex and constricted anteriorly 5

   Middle three abdominal sternites constricted in central portions; form of body subcylindrical; antenna often slender .... **Cryptocephalinae**

5(4). Wing venation greatly reduced; cubital veins lacking; clypeus divided into two parts; body rounded and depressed .... **Chrysomelinae**

   Wing venation not reduced; cubital

veins present; clypeus not divided; body very convex; elytra often broader than prothorax . . . . **Eumolpinae**

Subfamily *CRYPTOCEPHALINAE*

KEY TO FIJIAN GENERA OF CRYPTOCEPHALINAE

1. Antenna generally much shorter than body, usually thickened distally; pygidium not conspicuously exposed (MONACHINI) 2

   Antenna generally nearly as long as body, slender; pygidium more or less conspicuously exposed (CRYPTOCEPHALINI); prosternum dilated forward toward mouth parts . . . . **Loxopleurus**

2(1). Dorsum glabrous and shiny, lacking scale-like hairs; pronotum not produced over scutellum 3

   Dorsum often bronzy, clothed with small scale-like hairs; pronotum produced over scutellum, sometimes hiding it . . . . **Pycnophthalma**

3(2). Prothorax more or less collared at apex, generally also punctured or grooved parallel to basal margin; scutellum narrow, tapering . . . . **Coenobius**

   Prothorax rarely margined or collared at apex, rarely punctured or margined parallel to basal margin; scutellum short, scutiform . . . . **Ditropidus**

Tribe MONACHINI

Genus COENOBIUS Suffrian

Coenobius Suffrian, 1857, Linn. Ent. 11: 61 (type: *C. triangulum* Suffr.; Africa).

Head broad and depressed, epistoma joined with the front. Eyes large, strongly notched, touching each other. Antenna short, first segment oblong ovate, second shorter and more slender, the six apical dilated. Prothorax contracted in front, somewhat convex, all the angles well marked, posterior margin serrate with a median lobe not very prominent. Scutellum with the sides parallel on basal two-thirds, converging to the apex, which is slightly raised. Elytron convex near scutellum, slanting steeply at side, shoulder prominent and epipleuron well marked; surface evenly punctate-striate. Prosternum one and a half times broader than long, slightly produced at anterior margin, with a marginal impression, posterior margin emarginate, with lateral angles prominent. Legs short; tarsi with third segment strongly notched, claw segment almost entirely engaged in the preceding and claws dilated and toothed basally.

KEY TO FIJIAN SPECIES OF *Coenobius*

1. Anterior end of prothorax less than three-fifths as broad as base of prothorax 2

   Anterior end of prothorax more than three-fifths as broad as base; pronotum pale, sparsely punctured; elytron darkened in scutellar area . . . . **geniostomae**

2(1). Dorsum, or at least elytron, dark pitchy 3

   Dorsum largely pale reddish testaceous, rarely marked with pitchy black on border, or outer portion, of disc of elytron 4

3(2). Pronotum more or less vertical at side and with a distinct oblique groove, generally pitchy with side paler; posterior process of pronotum emarginate; elytron punctured in grooved rows above as well as at side . . **zimmermani**

   Pronotum not vertical at side and without an oblique groove, the lateral margin distinctly flattened, generally entirely dark except for anterior collar, but sometimes with basal portion slightly paler; posterior process of pronotum large, not emarginate; elytron smooth above, with four distinct grooves at side . . . . **producticollis**

4(2). Discal punctures of elytron in part as large as interspaces; prothorax distinctly grooved at side; frons nearly

impunctate.......................
.....**marginipennis marginipennis**
Discal punctures of elytron much smaller than interspaces; prothorax feebly grooved at side; frons distinctly punctate....**marginipennis lauensis**

1. ***Coenobius geniostomae*** Gressitt, n. sp.

FEMALE: Testaceous, largely transluscent or transparent, somewhat ochraceous on center of pronotum and middle of metasternum; elytron blackish on base and suture and obliquely on scutellar portion, and pitchy on outer margin; antenna pale on scape, dull ochraceous on next four segments, pitchy on remainder.

Head flat in front, round in outline, sparsely punctured on frons. *Antenna* two-thirds as long as body, fairly slender; scape fully as long as next two segments together; third slightly longer than second, fourth, and fifth; following longer and stouter, subequal. *Prothorax* five-eighths as long as broad, broad anteriorly, shiny, sparsely punctured, obliquely grooved at side; basal margin produced and emarginate opposite scutellum. *Scutellum* slender, narrowed apically. *Elytron* slightly narrowed between postbasal and preapical portions, distinctly punctured in regular rows, the punctures in most cases much narrower than interpunctural rows. *Ventral surfaces* closely punctured on side of thorax and second and following abdominal sternites; first sternite nearly as large as remainder of abdomen. First hind tarsal segment as long as next two combined. Length 2.5 mm.; breadth 1.5 mm.

VANUA LEVU: Holotype, female (BISHOP 2403), between Navakuru and Nakawanga, 300 m., on *Geniostoma vitiense*, Oct. 7, 1955, Gressitt; paratype, female, same data.

HOST: *Geniostoma vitiense* Gilg and Benedict.

Differs from *C. marginipennis* Bryant in being stouter, with the prothorax shorter and broader anteriorly, the antenna partly darkened, and the elytron punctured but not grooved. The paratype lacks the black on scutellar portion of the elytral disc.

2. **Coenobius marginipennis marginipennis** Bryant

Coenobius marginipennis Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 249. (Vanua Levu; type in Brit. Mus.)

Pale fulvous; elytron narrowly margined with fuscous; antenna with five basal segments fulvous and six apical segments tinged with fuscous.

Head impunctate; eyes meeting above. *Antenna* with six apical segments broader; scape nearly as long as second to fourth combined. *Prothorax* shiny, transversely grooved near anterior margin; side with an oblique groove; base produced into a lobe at middle. Scutellum impunctate, narrowly elongate. *Elytron* finely punctate-striate, interstices at side slightly convex. *Pygidium* closely punctured and clothed with very fine golden pubescence. First abdominal segment very long; second and third short and equal; last about equal to second and third combined. Length 2.5 mm.

VITI LEVU: Thuvu, Lautoka (after Bryant); nineteen, Lami Quarry, near Suva, Feb. 1951, Krauss; ten, Raki Raki, Lami, Lautoka, and Ndeumba, Jan. and Mar. 1955, Krauss.

VANUA LEVU: Type from Lambasa. Sixteen, eight, east of Lambasa, on *Glochidion cordatum*, Oct. 6, 1955, Gressitt; four, Nakawanga, on *Glochidion ramiflorum*, Oct. 8, 1955, Gressitt.

TAVEUNI: After Bryant.

HOSTS: *Glochidion cordatum* (Muell. Arg.) Seem.; *G. ramiflorum* Forst.

3. ***Coenobius marginipennis lauensis*** Gressitt, n. subsp.

Fig. 1

MALE: Pale ochraceous, slightly duller on distal half of antenna, narrowly pitchy on basal margin of prothorax. Legs and ventral surfaces sparingly clothed with short suberect pale hairs.

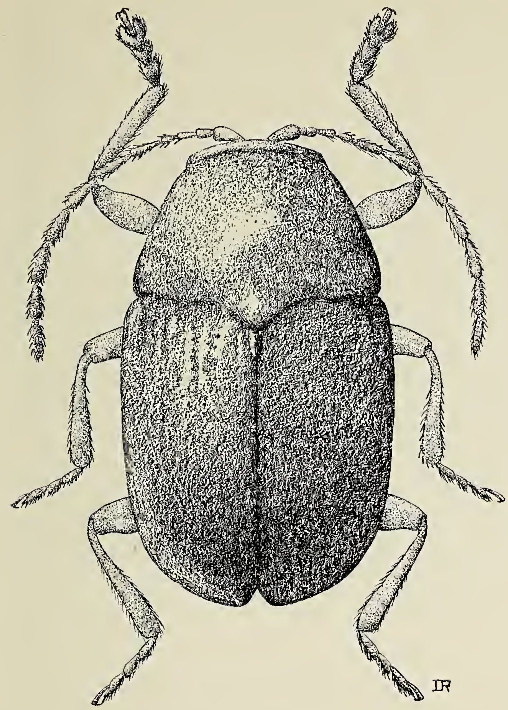

FIG. 1. *Coenobius marginipennis lauensis* Gressitt, n. subsp.

Head moderately punctured; eyes touching above. *Antenna* three-fourths as long as body, sixth and following segments thickened. *Prothorax* shiny, feebly punctured, feebly grooved at side. *Scutellum* subelliptical, about three times as long as broad. *Elytron* with ten regular rows of punctures which are mostly much smaller than spaces between them, longitudinally and transversely. *Ventral surfaces* in part punctured, largely impunctate on metasternum and first abdominal sternite. *Pygidium* closely punctured. Length 2.4 mm.; breadth 1.35 mm.

FEMALE: *Antenna* three-fifths as long as body; last six segments moderately thickened and pitchy. Length 2.5 mm.; breadth 1.6 mm.

LAU: Holotype, male (BISHOP 2385), Naiau I., Fiji, Sept. 12, 1924, E. H. Bryan, Jr.; allotype , female (BISHOP), by seashore near Loma Loma, Vanua Mbalavu I., Aug. 7, 1938, Zimmerman.

KANDAVU: A third specimen, male, from Kaivala, Apr. 29, 1941, Krauss, is also referred to this subspecies.

Differs from *C. marginipennis marginipennis* Bryant in being larger, entirely testaceous except for antenna, and in having the frons punctured, the pronotum less distinctly grooved at side, and the elytral punctures mostly much smaller than spaces between them.

4. ***Coenobius producticollis*** Gressitt, n. sp.
Fig. 2*a*, *b*

MALE: Reddish brown to dark pitchy, largely pitchy above; ventral surfaces slightly paler; base of antenna, front of head, and legs testaceous; fourth and following antennal segments gradually darked, last nearly black; pygidium brown. Antenna, legs, and ventral surfaces sparingly clothed with short oblique pale hairs.

Head finely and irregularly punctured, somewhat raised on frons; eyes touching above. *Antenna* three-fourths as long as body, last five segments moderately thickened; scape hardly as long as second and third segments combined; second to fourth subequal in length, second more swollen. *Prothorax* just over two-thirds long as broad, much wider near base than at apex; lateral margin flattened, broadly expanded basally; apical collar moderately developed; median basal process

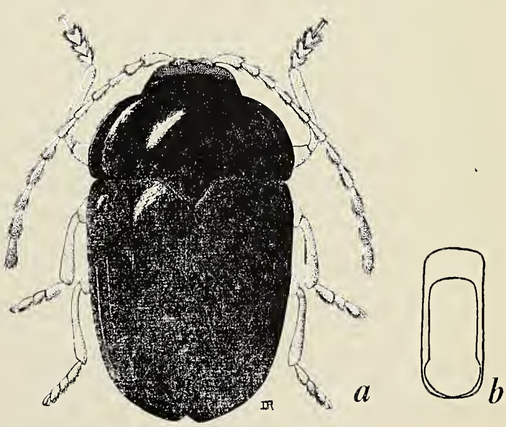

FIG. 2. *Coenobius producticollis* Gressitt, n. sp.; *a*, type; *b*, aedeagus.

well developed, subacute; disc convex, nearly impunctate, shiny, feebly grooved obliquely near middle of side of basal margin. *Scutellum* small, suboblong, about twice as long as broad. *Elytron* nearly impunctate, and ungrooved, on upper portion of disc, but with four deep grooves, hardly punctured, at side, none of which reach apex. *Ventral surfaces* sparingly punctured. *Pygidium* moderately punctulate. *Legs* short and stout. Length 1.65 mm.; breadth 0.94 mm.

FEMALE: Dorsum slightly paler on elytron. Antenna two-thirds as long as body. Length 2 mm.; breadth 1.1 mm.

VITI LEVU: Holotype, male (BISHOP 2398), ridge west of Vatuthere, alt. 900 m., Nandarivatu, Sept. 8, 1938, beating, Zimmerman; allotype, female (BISHOP), Nandarivatu, 1100 m., Sept. 6, 1938, Zimmerman. Two paratypes, male and female (BM), same data as allotype.

OVALAU: Two paratypes, both females (BISHOP), Andubangda, 600 m., Aug. 15, 1938, Zimmerman.

The Ovalau specimens have the pronotum paler, particularly apically and basally.

Differs from *C. marginipennis* Bryant in being smaller, darker, with the prothorax less convex, more broadly expanded on lateral margin, less punctate above, and more grooved at side.

5. *Coenobius zimmermani* Gressitt, n. sp.

Fig. 3

MALE: Dark chestnut brown to pitchy; head, legs, and last abdominal sternite testaceous; antenna testaceous basally, pitchy on last six segments. Ventral surfaces sparingly clothed with short pale hairs; antenna more densely clothed.

Head with a few punctures; frons narrow and slightly raised; eyes touching above, deeply emarginate. *Antenna* three-fourths as long as body; scape longer than second and third segments combined; second much shorter than third; last six segments thickened. *Prothorax* two-thirds as long as broad, practically as broad as elytra, strongly narrowed anteriorly, distinctly collared at apex; disc sparsely and shallowly punctured, distinctly grooved obliquely at side. *Scutellum* slender, narrowed posteriorly, more than twice as long as broad. *Elytron* moderately punctured in ten distinct grooves, the last two deep; most of punctures smaller than spaces between them longitudinally. *Ventral surfaces* sparingly punctured, densely punctured on metepisternum, and moderately so on last abdominal segment. *Legs* fairly stout. Length 1.92 mm.; breadth 1.2 mm.

FEMALE: Pronotum pale on each side; ventral surfaces testaceous except for pitchy metasternum. Length 2.28 mm.; breadth 1.2 mm.

Paratypes: Length 1.2–2.4 mm.; breadth 0.93–1.3 mm.

OVALAU: Holotype, male (BISHOP 2399), Andubangda, 600 m., July 15, 1938, Zimmerman; allotopotype, female (BISHOP), same data; four paratopotypes, two males and two females (BISHOP, BM), same data.

Differs from *C. producticollis* in being slightly larger, with ventral surfaces paler, the pro-

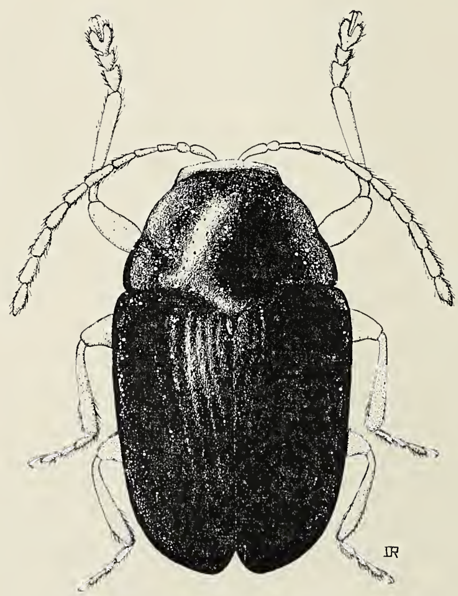

FIG. 3. *Coenobius zimmermani* Gressitt, n. sp.

thorax less expanded at side, less produced at middle of base, and with the elytron having ten distinct grooves, all punctured, with only the outer two grooves deep.

Genus DITROPIDUS Erichson

Ditropidus Erichson, 1842, Arch. f. Naturgesch. 8(1): 120.

Pleomorpha Saunders, 1847, Ent. Soc. London, Trans. 4(4): 268.

Broadly ovate. Eyes large, nearly touching. Antenna moderately thickened, barely more than one-half as long as body. Prothorax strongly convex, not distinctly collared apically or grooved parallel to base, with a prominent basal process covering base of scutellum. Scutellum scutiform. Elytron seriate-punctate, hardly grooved, with epipleuron broad basally.

6. **Ditropidus punctulatus** Chapuis?

Ditropidus punctulum Chapuis, 1876, Soc. Ent. de Belg., Ann. 18 C. R.: LXXX (Australia, Fiji).

MALE: Dark reddish pitchy; legs testaceous; antenna testaceous with apex slightly dusky. Ventral surfaces, legs and antenna with short oblique goldish hairs.

Head finely punctured; frons raised, flat. *Antenna* three-fifths as long as body; scape longer than next two segments combined; eighth to tenth segments nearly as broad as long. *Prothorax* evenly convex, considerably narrowed apically, sparsely and minutely punctured; posterior process bluntly rounded apically. *Scutellum* short, scutiform. *Elytron* with ten rows of small distinct punctures, the largest punctures somewhat longitudinal, and nearly as long as interspaces longitudinally. *Pygidium* finely punctured; ventral surfaces moderately punctured. Length 1.5 mm.; breadth 1 mm.

LAU: Mvana, Vanua Mbalavu, 60 m., Aug. 1938, Zimmerman, three males.

7. **Ditropidus tibialis** Chapuis

Ditropidus tibialis Chapuis, 1876, Soc. Ent. de Belg., Ann. C. R. 18: LXXIX (Australia, Fiji).

This species was recorded long ago from Fiji, but seems to be lacking in the present collection.

DISTRIBUTION: Southeastern Australia, Fiji.

Genus PYCNOPHTHALMA Maulik

Pycnophthalma Maulik, 1929, Insects of Samoa 4 (3): 180 (type: *P. tutuilana* Maulik; Samoa).

Body ovate. Eyes large, touching each other on upper side of head, deeply emarginate. Antenna 11-segmented, extending almost to the middle of the body; six apical segments thickened. Prothorax narrow in front; base not margined, edge with serrations, part opposite scutellum produced into a lobe which ends in an acute point; side margined, anterior and posterior angles rounded. Scutellum visible from above, narrow, oblong with rounded apex and base fitting against point of prothoracic lobe. Elytra not broader at base than prothorax, each punctate-striate, punctures deeply imbedded in grooves, striae appear at least on discal area, to be inclined toward the suture. Viewed from above the pygidium not exposed. Underside with intercoxal process of prosternum almost quadrate or slightly longer than broad, with surface rough and coarsely pitted; sides margined, and posterior edge widely arched. Epipleuron of elytron broader at base and narrowed from middle to apex. Legs fairly stout, not long, so that when withdrawn they are not visible from above. Claw segment of tarsus projecting a little beyond bilobed segment; claws appendiculate.

KEY TO FIJIAN SPECIES OF *Pycnophthalma*

1. Scutellum not completely hidden; dorsum pitchy reddish to bronzy, with silvery and golden to grayish pubescence 2

Scutellum completely hidden; dorsum reddish coppery with golden bronzy pubescence, feebly depressed between prothorax and elytra......... **cuprea**

2(1). Pronotum not deeply impressed near anterior margin except at side, distinctly depressed basally in lateral outline; dorsum pitchy reddish with varicolored scales; femora pale........ 3

Pronotum deeply impressed near anterior margin; elytra bronzy black with grayish silvery scales; femora black.. .... **leveri**

3(2). Body outline somewhat pentagonal; elytral apex pale reddish; base of prothorax distinctly depressed on each side of median process....... **apicale**

Body somewhat regularly oval in outline; elytral apex not very pale; base of prothorax feebly depressed on each side of median process.. **aureopilosus**

8. Pycnophthalma cuprea Bryant

Pycnophthalma cuprea Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 508 (Fiji).

MALE: Dark bronzy pitchy, more reddish beneath; antenna testaceous basally, brownish distally; legs testaceous. Body clothed above with short oblique bronzy golden hairs, turning to silvery on side and apex of elytron.

Head with frons raised and micropunctulate. *Antenna* barely over one-half as long as body; scape as long as next two segments combined; last six segments each about as broad as long. *Prothorax* nearly twice as broad as long, obtusely rounded anteriorly; disc subclosely and distinctly punctured. *Scutellum* hidden. *Elytron* with regular rows of close longitudinal punctures, with interspaces somewhat closely punctured. *Ventral surfaces* unevenly punctured. Length 1.8 mm.

FEMALE: Antenna less than one-half as long as body. Length 2 mm.

VITI LEVU: Mt. Victoria, 1000 m., Tholo North, Sept. 1938, Zimmerman, 28 specimens.

9. *Pycnophthalma aureopilosa* (Bryant), n. comb.

? *Coenobius aureopilosus* Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 591 (Fiji; type in Brit. Mus.).

Pitchy brown, with dull golden, varying to silvery pubescence, above.

Head with eyes nearly touching; frons finely rugose-punctate, somewhat raised in middle. *Antenna* more than one-half as long as body in male, less than one-half as long in female; last six segments somewhat longer than broad. *Prothorax* fully two-thirds as long as broad, finely and closely punctured, distinctly depressed basally, and obliquely from base along side. *Scutellum* elliptical, a little longer than broad, smooth, concave basally. *Elytron* with distinct rows of elongate punctures, and fine punctures between rows. *Ventral surfaces* in part sparsely punctured. Length 1.9 mm.

VITI LEVU: Nandarivatu, 1100 m., Sept. 1938, Zimmerman (two), and Navai-Nasonga trail, 900 m., Sept. 1938, Zimmerman (one).

10. *Pycnophthalma apicale* Bryant, n. sp.

Fig. 4

Upperside metallic bronze-green, with apex of elytron narrowly flavous, clothed with short golden pubescence; elytron with side margin and apical half of suture showing white silky pubescence. Legs and antenna flavous.

MALE: *Head* with median portion clothed with short whitish pubescence, clypeus flavous, eyes large, touching at base. *Antenna* extending just beyond the base of elytra, flavous, first segment more than twice as long as second, third more slender and longer than second, the remainder about equal, six apical segments slightly thickened. *Prothorax* bronze-green, with dense short golden pubescence, transverse, widest at base, the base produced in a lobe opposite scutellum, sides rounded and contracted in front. *Scutellum* oblong very narrow. *Elytron* metallic bronze-green, apex

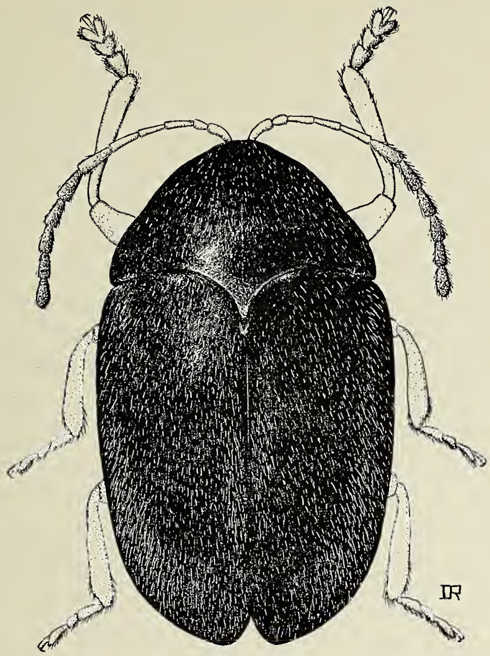

FIG. 4. *Pycnophthalma apicale* Bryant, n. sp.

narrowly flavous, clothed with short golden pubescence, except side margin and apical half of suture, which show short white silky pubescence, widest at base and slightly narrowed to apex. *Legs* flavous. *Underside* pitch black, clothed with very fine pubescence, with apical ventral segment flavous. Smaller than the female. Length 2–2.5 mm.; breadth 1.2–1.4 mm.

VITI LEVU: Holotype, male (BISHOP 2400), Nandarivatu, Viti Levu, 900–1000 m., Fiji, Sept. 3–6, 1938, Zimmerman; allotopotype, female and four paratopotypes, three males and one female, same data. One male paratype, Navai-Nasonga trail, west slope, 750–900 m., Sept. 12, 1938, Zimmerman; one female paratype, Mt. Victoria, west slope, Tholo North, 900–1200 m., Sept. 13, 1938, Zimmerman.

Allied to *P. cuprea* Bryant, but differs in the color and arrangement of the pubescence on the elytron, and in having the apex of the elytron flavous.

11. **Pycnophthalma leveri** Bryant

Pycnophthalma leveri Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 509 (Fiji; type in Brit. Mus.).

Dorsum bronzy; venter black; pronotum clothed with fine pubescence; elytron with small grayish silvery scales. *Head* impunctate; *antenna* reaching slightly beyond base of elytron; scape nearly twice as long as pedicel; third to fifth segments more slender, each longer than second and about equal to each other, the terminal segments slightly thickened. *Pronotum* bronzy with very fine punctures and fine scattered pubescence; front margin deeply impressed; side feebly margined. *Scutellum* oblong and very small. *Elytron* bronzy, clothed with very small grayish silvery scales, very finely punctate-striate, the three striae near side margin deeper. *Legs* with femora black, tibiae and tarsi flavous. Length 2 mm.

VITI LEVU: Nandarivatu (type series).

Tribe CRYPTOCEPHALINI

Genus LOXOPLEURUS Suffrian

Loxopleurus Suffrian, 1859, Linn. Ent. 13: 125; Chapuis, 1874, Gen. Col. 10: 186.

Head of medium size, engaged in prothorax; labrum large, free and almost entire; eye rather large, canthus triangular, measuring half the breadth of an eye. Antenna filiform, very slightly compressed towards the apex, shorter than the body in both sexes, extending half the length of body in female. Prothorax contracted in front, produced towards anterior angles, somewhat convex on disc, and slightly produced in middle of anterior border, side margin almost straight, entire, a little raised, posterior margin with a median lobe, two strong impressions near the scutellum, diverging towards anterior angles. Scutellum oblong, apex somewhat raised, an impression at base. Elytron elongate, subcylindrical, slightly broadening behind, epipleural lobes not prominent, shoulders well marked, with a lateral compression of the body, surface punc-

tate-striate, the rows sometimes confused and indistinct towards base. Prosternum with anterior border a little swollen opposite mouth parts, somewhat dilated behind anterior coxa, obliquely truncate on each side and forming a pentagon of which the summit rests on mesosternum. Legs slender; tarsi rather long, three basal segments triangular, subequal, claw segment terminated by two slender claws, dilated and sinuous at base.

KEY TO FIJIAN SPECIES OF *Loxopleurus*

1. Length 2.6–3.6 mm.; center of pronotal disc and elytral base generally dark; elytron generally with outer margin or a postmedian band also dark 2

   Length 2.0–2.5 mm.; pronotum and elytron generally each uniformly pale or dark, or elytral disc dark with margins pale, or vice versa 3

2(1). Frons coarsely punctured, raised at side; pronotum almost impunctate; elytral punctures feeble . . . . . **vitiensis**

   Frons slightly convex, moderately punctured; pronotum punctured; elytral punctures distinct . . . . **rotumanus**

3(1). Elytral intervals not raised; pronotum and elytron generally each uniformly pale or dark 4

   Elytral intervals slightly costate; flavous, a median pronotal and sutural stripe of blackish . . . . **costipennis**

4(3). Prothorax orange or yellowish; elytron entirely shiny blackish; abdomen black . . . . **ruficollis**

   Pronotum pale; elytron with disc largely dark and borders pale; abdomen yellow . . . . **leveri**

12. Loxopleurus costipennis Bryant

Loxopleurus costipennis Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 421, fig. 2 (Fiji; type in Brit. Mus.).

MALE: Flavous; last six antennal segments black and pubescent; pronotum with a median black stripe, broadest at anterior margin, gradually narrowing to a point at base; scutellum black; elytron with basal margin and suture narrowly black; ventral surfaces with fine golden pubescence, apical segment paler.

Head impunctate; eye strongly notched. *Antenna* reaching middle of elytron; scape longer than second and third segments combined. *Prothorax* with a very few fine scattered punctures and an oblique impression just behind middle of side. *Elytron* punctate-striate with intervals slightly costate.

FEMALE: Larger; black markings less well defined. Length: 2–2.5 mm.

VITI LEVU: Suva; type series taken by Lever. A male, Nandarivatu, Jan. 1955, Krauss; a male, Rewa, Feb. 1952, Gressitt.

LAU: One female, Loma Loma, Vanua Mbalavu I., Aug. 1938, Zimmerman, is tentatively referred here.

13. Loxopleurus leveri Bryant

Loxopleurus leveri Bryant, 1943, Ann. and Mag. Nat. Hist. Ser. 11, 10: 567 (Fiji; type in Brit. Mus.).

FEMALE: Testaceous; distal antennal segments brownish apically; elytral disc pitchy brown. *Head* feebly punctured on frons; eyes touching above. *Antenna* nearly three-fourths as long as body, slightly thickened distally. *Prothorax* nearly as broad as elytra, seven-ninths as long as broad, smooth and shiny; shallowly and obliquely grooved at side. *Elytron* feebly punctate-striate, with outer grooves more distinct. *Ventral surfaces* partly punctured at side. Length 2.65 mm.

LAU: Mvana, Vanua Mbalavu, Aug. 1938, beating shrubs, Zimmerman.

14. *Loxopleurus ruficollis* Bryant, n. sp.

Fig. 5

Black, the head, prothorax and legs rufous, prothorax nitid with a few scattered punc-

tures, elytron black, nitid, punctate-striate. Length 2.0–2.5 mm.

MALE: *Head* rufous, slightly rugose between antennal bases, eye reniform. *Antenna* extending almost to middle of elytron, seven basal segments flavous, apical four slightly fuscous, first segment slightly more dilated than second. *Prothorax* rufous, nitid, with a few scattered punctures, widest at base, side slightly contracted behind middle then slightly widening and contracted in front. *Scutellum* black, narrowly oblong, impunctate. *Elytron* black, nitid, punctate-striate, widest at base, gradually tapering to apex. *Underside* with prosternum rufous, abdominal sternites black, nitid. *Legs* flavous.

FEMALE: Differs in its slightly larger size, and a deep fovea in the apical ventral segment.

VITI LEVU: Holotype, male (BISHOP 2401), Korovou, Tailevu, Sept. 20, 1939, Valentine; allotopotype and one paratopotype (BISHOP, BM), same data. One female paratype, ridge west of Nandarivatu, Sept. 11, 1938, Zimmerman; another from Lami, Mar. 1951, Krauss.

LAU: One male, Vanua Mbalavu, Mvana, Aug. 9, 1938.

OVALAU: One male, Andubangda, July 15, 1938, Zimmerman.

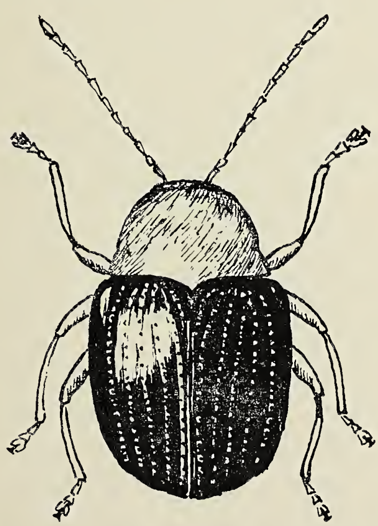

FIG. 5. *Loxopleurus ruficollis* Bryant, n. sp.

Somewhat allied to *L. leveri* Bry., but smaller, the color pattern is different, and the elytra are more strongly punctate-striate.

15. **Loxopleurus vitiensis** Bryant

Loxopleurus vitiensis Bryant, 1943, Ann. and Mag. Nat. Hist. Ser. 11, 10: 566.

MALE: Testaceous to reddish brown, variable; often with a broad reddish band across pronotal disc, a similar one across elytral base, and a narrower one behind middle of elytra. *Head* grossly punctured; eyes contiguous above. *Antenna* three-fourths as long as body, slightly flattened distally. *Prothorax* nearly as broad as elytra, smooth and shiny, with an oblique groove on side. *Elytron* feebly seriate-punctuate; last three rows more deeply punctured and slightly grooved. *Ventral surfaces* in part densely punctured. Length 2.6–2.9 mm.

FEMALE: *Antenna* three-fifths as long as body. Length 3–3.6 mm.

VITI LEVU: Mt. Victoria, west slope, Tholo North, Naivithula, Tailevu, Sept. 1937, Valentine; Tholo-i-suva, June 1924, Bryan and July 1938, Zimmerman; Nandarivatu, Sept. 1938, Zimmerman; Lami Quarry, July 1938, Zimmerman and May 1951, Krauss; near Suva, Feb. 1952, Gressitt.

16. ***Loxopleurus rotumanus*** Gressitt, n. sp.

Fig. 6

FEMALE: Testaceous; occiput pitchy; pronotum with a large central vaguely bordered pitchy area; scutellum ochraceous; elytron testaceous with basal, external, and apical margins broadly pitchy, and suture very narrowly reddish; ventral surfaces entirely pale except for posterior margins of first three abdominal sternites.

Head with a few punctures on frons, which is subtriangular and somewhat raised; eyes nearly touching above, each deeply emarginate near middle. *Antenna* three-fifths as long as body; last six segments slightly thickened; scape longer than second and third

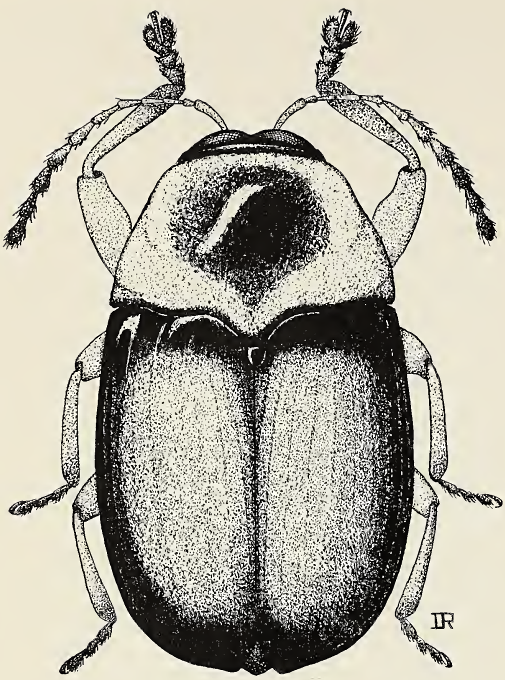

FIG. 6. *Loxopleurus rotumanus* Gressitt, n. sp.

segments combined; third distinctly longer than second or fourth. *Prothorax* nearly as broad as elytron, seven-ninths as long as broad, constricted, but not very distinctly collared, near apex; disc shiny, sparsely and shallowly punctured, obliquely grooved at side; median basal process emarginate. *Scutellum* suboblong, twice as long as broad, smooth. *Elytron* with ten rows of fine punctures, including sutural row, besides an oblique row between sixth and seventh regular rows; outer three rows in distinct grooves, the last two complete. *Ventral surfaces* in large part finely and not very closely punctured, and with short erect pale hairs; metepisternum finely rugulose; last abdominal sternite densely punctured except in the large central cavity. Length 3.5 mm.; breadth 2 mm.

ROTUMA: Holotype (BISHOP 2402) Jolmea, Rotuma Island, north of Fiji Islands, Aug. 13, 1938, H. St. John.

Differs from *L. vitiensis* Bryant in being stouter, with shorter antenna, more punctate pronotum and elytron, and with different markings, having the pronotum with a large central pitchy area and the elytron pale with broad dark borders except along suture.

17. **Cryptocephalus fraterculus** Chapuis

Cryptocephalus fraterculus Chapuis, 1876, Soc. Ent. de Belg., Ann. C. R. 18: XCI (Fiji).

This species was described from Fiji, but has not been identified from the material at hand.

Subfamily *EUMOLPINAE*

The study of the Fijian members of this subfamily has proved most difficult. To adapt the Fijian material to most of the previously used classifications would have required the erection of a number of new genera or tribes. On the basis of the material at hand, it would appear that many characters used in the past as tribal characters do not deserve that value. Therefore, a compromise has been made, which cannot be considered a final or satisfactory treatment, but one that may serve until the faunae of the island groups to the west are better known in this family. In the main, the system proposed by Chen (1940: 486 ff.) has been followed, though it does not quite satisfactorily solve the problem. It has involved a reduction from eight or more tribes to three. Some of the old tribal names are inserted in parentheses in the text.

KEY TO FIJIAN GENERA OF EUMOLPINAE

1. Apical tergite of abdomen with a median longitudinal groove; generally glabrous above; tarsal claws appendiculate; middle and hind tibiae not emarginate preapically (Colaspoidini) 2
   Apical tergite of abdomen lacking a median longitudinal groove; tarsal claws generally bifid; middle and hind tibiae generally emarginate preapically 3

2(1). Elytron regularly seriate-punctate; body just over one-half again as long as broad . . . . **Eucolaspis**

Elytron irregularly punctured; body more than twice as long as broad. . . . . **Colaspoides**

3(1). Prothorax generally without distinct lateral margin, but if margined then dorsum is clothed with fine scales or hairs and also base of prothorax is much narrower than elytra (Adoxini) 4

Prothorax generally with a distinct lateral margin, but if unmargined then dorsum is generally glabrous (Nodinini) **6**

4(3). Dorsum more or less pubescent, not exceedingly rough; legs not very long 5

Dorsum partly glabrous, exceedingly rough, with tubercles, nodes and heavy punctures; legs quite long. . . . . **Damelia**

5(4). Head narrower than prothorax; gena distinct; prothorax sometimes slightly margined at side; aedeagus more or less oblong, fairly broad. . . . . **Demotina**

Head as broad as prothorax, very short, with minute gena; prothorax unmargined at side; aedeagus slender and acuminate apically . . . . **Parademotina**

6(3). Prothorax narrower than elytra, or dorsum more or less glabrous, or length more than 4 mm. 7

Prothorax practically as broad as elytra, distinctly margined; dorsum pubescent; body length less than 3 mm. . . . . **Stygnobia**

7(6). Prothorax nearly as broad as elytra, distinctly margined at side; dorsum generally glabrous, but rarely pubescent 8

Prothorax narrower than elytra, feebly margined or not margined at side; dorsum glabrous or with very fine indistinct hairs *9*

8(7). Prothorax somewhat rounded anteriorly and rounded at side; elytron seriately or irregularly punctured; dorsum glabrous or pubescent. . . . . **Rhyparida**

Prothorax trapeziform, projecting at anterior corners; elytron seriatepunctate; dorsum glabrous . . . . **Lindinia**

9(8). Scutellum normal **10**

Scutellum transversely rectangular with prominent posterior angles. . . . . **Labasa**

10(9). Humerus not paricularly prominent; body less than 8 mm. long **11**

Humerus prominent; body length 10 mm. or more . . . . **Eurydemus**

11(10). Body narrow or elytra attenuated posteriorly; generally blackish and deeply punctured; some fine hairs on pronotum or elytron **12**

Body not particularly narrow; varying in color, often partly pale; rarely very heavily punctured; dorsum glabrous . . . . **Vitibia**

12(11). Elytra more or less attenuated posteriorly, not parallel-sided; elytron with fine subrecumbent hairs parallel to suture, and sometimes also with suberect hairs; pronotum glabrous . . . . **Stethotes**

Body narrow, parallel-sided; elytron glabrous; pronotum finely and sparsely pubescent; head grooved above eye . . . . **Epinodostoma**

Tribe NODININI

(METACHROMINI)

Genus LINDINIA Lefevre

Lindinia Lefevre, 1893, Soc. Ent. de France, Ann. 62(3). Bul. CCLXVI (type: *L. reflexoaenea* Lef.; Philippines).

Robust; head short, with frons transverse; antenna fairly slender; prothorax short, subrectangular; elytra a little broader than prothorax.

This genus is primarily Philippine.

18. *Lindinia glabrata* Bryant, n. sp.
Fig. 7

Glabrous, rufous, with the exception of fuscous tibiae and eight apical antennal segments; elytron very finely and feebly punctate-striate.

MALE: *Head* rufous and glabrous, a median longitudinal impression on vertex not extending to the base. *Antenna* extending to middle of elytron, three basal segments fulvous, the remainder fuscous, two basal segments more dilated, the third long and slender, about equal to the first two; third to fifth about equal; sixth to eleventh slightly thickened and more pubescent. *Prothorax* rufous and glabrous, widest at base, the sides feebly rounded and contracted in front. *Scutellum* rufous, impunctate, rounded at the apex. *Elytra* rufous, glabrous, but very finely and feebly punctate-striate, wider than base of prothorax, the sides parallel and beyond the middle rounded to apex. *Legs* rufous with tibiae slightly fuscous, intermediate and posterior pair emarginate at apex. Underside rufous and glabrous, first ventral segment of abdomen longest, second to the fourth shorter and equal to each other. Length 6 mm.

VITI LEVU: Holotype (BISHOP 2404) Navai Mill, near Nandarivatu, Viti Levu, Fiji, Sept. 17, 1938, 800 m., Zimmerman. One paratype, Nandarivatu, 1100 m., Sept. 5, 1938, Y. Kondo.

Closely allied to *L. tibialis* Lef., but differs in the less closely punctate striae, and in not having the legs and mesosternum black.

FIG. 7. *Lindinia glabrata* Bryant, n. sp.

Genus RHYPARIDA Baly

Rhyparida Baly, 1861, Jour. Ent. 1: 286 (type: *R. dimidata* Baly; Australia).

Marsaeus Clark, 1864, Jour. Ent. 2: 252 (type: *Cryptocephalus didymus* Fabr.; Australia).

Head short, generally grooved on occiput; prothorax subquadrate, often trapeziform or rounded at side; elytra only slightly broader than prothorax, seriate or rarely irregularly punctured. Generally glabrous above, but some Fijian species are pubescent. The last four species treated below may require a new genus.

This large genus is distributed in Madagascar, Mauritius, Ceylon, Indonesia, Philippines, and to the Carolines, Samoa, and Australia, but appears to be centered in the Papuan subregion.

KEY TO FIJIAN SPECIES OF *Rhyparida*

1. Length of body more than 5 mm. . . . 2
   Length of body less than 4 mm.; elytron regularly punctured 7

2(1). Dorsum glabrous; elytron more or less seriately punctured 3
   Dorsum pubescent; elytron closely and irregularly punctured . . . . **luteola**

3(2). Pronotum rather densely punctured; elytron with puncture-rows somewhat irregular, very numerous and close, or punctures very large 4

Pronotum sparsely or very finely punctured; elytron with regular, widely spaced rows of fine punctures 5

4(3). Elytron with numerous, close, and slightly irregular puncture-rows; dorsum pitchy, slightly dull . . . . **laddi**

Elytron with very large punctures in slightly irregular rows; dorsum bright reddish brown, shiny . . . . **fijiensis**

5(3). Pronotum punctured, distinctly narrowed anteriorly; dorsum reddish to pitchy; elytron with interspaces somewhat convex 6

Pronotum impunctate, nearly as broad just behind apex as at base; dorsum shiny black, rarely reddish on elytron; elytral interspaces flat . . . **trapezicollis**

6(5). Reddish, with central portion of pronotal disc blackish; length of body less than 6 mm.; elytron less than three times as long as prothorax . . . . **dispar**

Pitchy black, slightly reddish on elytral bases; length of body more than 6.5 mm.; elytron more than three times as long as prothorax . . . . **oblonga**

7(1). Pronotum finely pubescent 8
Pronotum glabrous, flat, closely vermiculate-punctate; elytron glabrous, shiny reddish . . . . **vermiculata**

8(7). Elytron glabrous or very nearly so; pronotum smooth or longitudinally ridged between fine punctures 9

Elytron with minute scales or hairs; pronotum rather convex on disc, with dense punctures which are not arranged in longitudinal grooves; Lau I. . . . . **bryani**

9(8). Pronotal punctures largely in longitudinal or obliquely longitudinal grooves on side of disc; about 18 punctures in an approximate median longitudinal row; pronotal hairs fairly conspicuous; punctures in middle of second and third elytral rows separated transversely by spaces about three times as wide as punctures . . . . **kandavu**

Pronotal punctures not in grooves; about 12 punctures in an approximate median longitudinal row; pronotal hairs rather inconspicuous; punctures in middle of second and third elytral rows separated transversely by spaces barely wider than their diameters . . . . **strigosa**

19. Rhyparida dispar Bryant
Fig. 8*a*

Rhyparida dispar Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 593 (Labasa; type in Brit. Mus.).

Ochraceous-castaneous, middle portion of pronotum and an interrupted stripe on elytral

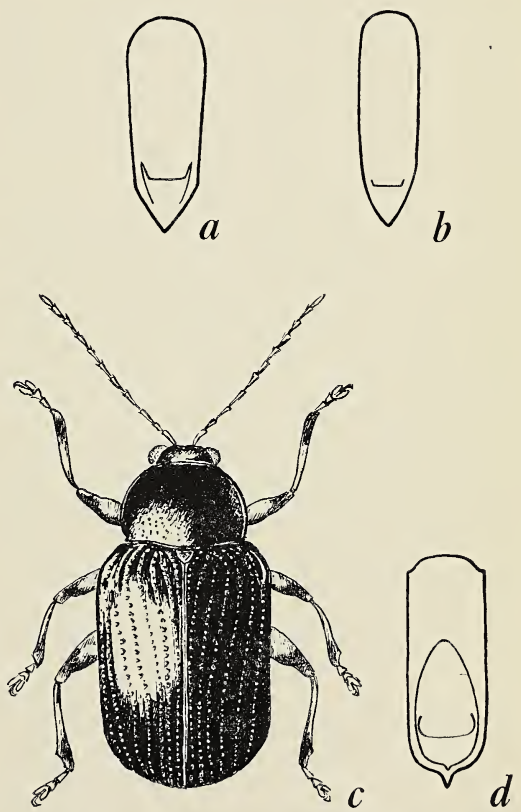

Fig. 8. *a*, *Rhyparida dispar*, aedeagus; *b*, *Rhyparida trapezicollis*, aedeagus; *c*, *Rhyparida oblonga* Bryant, n. sp.; *d*, *Rhyparida oblonga*, aedeagus.

disc pitchy. *Head* punctured throughout, grooved on occiput; *pronotum* moderately punctured, transverse; *elytron* deeply and regularly punctured. Length 4.5–5.7 mm.

VITI LEVU: Belt road west of Suva, July, Lami Quarry, near Suva, Aug., Mt. Korombamba, Aug., Nandarivatu, Sept. 1938, Zimmerman; Lami Quarry, Mar., May 1951, Krauss. Twelve specimens.

VANUA LEVU: Lambasa (type locality).

20. **Rhyparida trapezicollis** Fairmaire
Fig. 8*b*

Rhyparida trapezicollis Fairmaire, 1879, Le Naturaliste 1: 75 (Fiji); 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 484 (Ovalau; type in Paris Mus.).

Shiny black; reddish on antenna, tarsi, and sometimes elytron; palpi testaceous. Body fairly glabrous, except on antenna and legs. *Head* wrinkled and punctured; *pronotum* very sparsely and feebly punctured; *elytron* seriate-punctuate, but with the punctures in part very widely spaced, and mostly disappearing in apical third. Length 4.3–4.5 mm.

VITI LEVU: Belt road, 60–75 km. west of Suva, July 1938, Cooke and Zimmerman; Tholo-i-suva, July, ridge west of Nandarivatu, Sept. 1938, Zimmerman; Bulu, near Suva, Apr., Vunindawa, May 1941, Krauss.

OVALAU: Near Vuma, July 1938, Kondo; Thawathi, July 1938, Zimmerman.

VANUA LEVU: Nakawanga, and between Navakuru and Nakawanga, on *Dillenia* sp., and between Nakawanga and Mbangata, Oct. 7–9, 1955, Gressitt.

HOST: *Dillenia biflora* (A. Gray) Martelli.

21. ***Rhyparida oblonga*** Bryant, n. sp.
Fig. 8*c*, *d*

Elongate, more or less piceous, head marked with fulvous near eye and clypeus, rugosely punctured, prothorax transverse, with anterior margin narrowly fulvous, not closely punctured, elytron piceous margined with fulvous.

Head with a triangular piceous patch at the base, and transversely piceous between the insertion of antenna, and narrowly fulvous near eye and clypeus, rugosely punctured. *Antenna* fulvous, long and slender, extending beyond middle of elytron, the two basal segments more dilated, first longer than second, third long and slender, about equal to first two together, fourth slightly longer than third, remainder all about equal. *Prothorax* transverse, widest behind the middle, contracted in front, strongly but not closely punctured, piceous, with anterior margin fulvous. *Scutellum* fulvous, impunctate, rounded at apex. *Elytron* elongate, wider at base than prothorax, a short depression below base; piceous, slightly metallic, with base and side margins narrowly fulvous, strongly punctate-striate. *Legs* fulvous, slightly darker at apex of tibiae, and middle of femora, tibiae pubescent, intermediate and posterior tibiae emarginate at apex. *Ventral surfaces* more or less piceous, coxae fulvous, and apical ventral segments of abdomen tinged with fulvous. Length 6–7 mm.

VITI LEVU: Holotype (BISHOP 2405) Vatuthere, 800 m., Sept. 1938, under bark, Zimmerman; twelve paratopotypes, same data; one, Nandarivatu, Sept. 1938, Zimmerman. One taken under bark of *Agathis* sp. (kauri pine).

Differs from *R. dispar* Bryant in being larger, darker, with dorsum more deeply and closely punctured.

22. ***Rhyparida fijiensis*** Gressitt, n. sp.
Fig. 9

FEMALE: Reddish castaneous, ochraceous beneath and on antenna; pronotum with some small apparent blackish (transparent) spots. Antenna and legs with some short and some long oblique goldish hairs; ventral surfaces nearly glabrous.

Head distinctly punctured; frons subtriangular; vertex depressed; occiput feebly grooved. *Antenna* nearly three-fourths as long as body, slender; second segment two-thirds

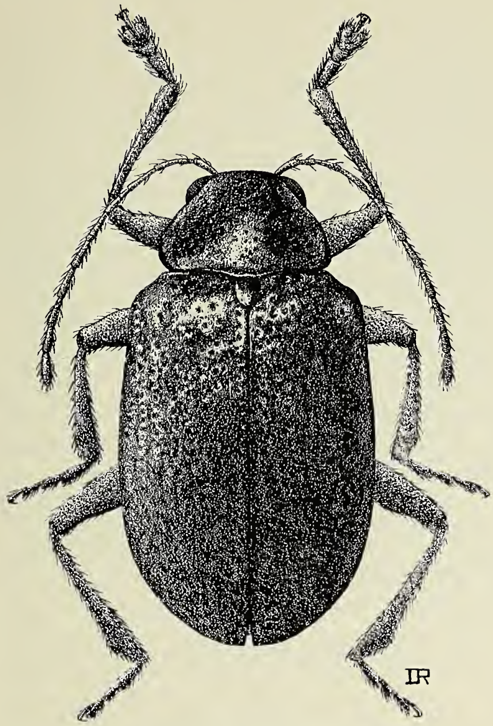

FIG. 9. *Rhyparida fijiensis* Gressitt, n. sp.

as long as scape; third nearly as long as scape; fourth longer than scape; fifth and following subequal. *Prothorax* five-sevenths as long as broad, convex in outline on four sides, somewhat narrower at apex than at base; disc rather coarsely punctured, somewhat closely so at side. *Scutellum* as long as broad, parallel-sided, rounded behind. *Elytron* slightly broadened to behind middle, then narrowed; disc coarsely punctured, almost foveate-punctate, in somewhat irregular, more or less complete, rows, the punctures mostly rather widely spaced. *Ventral surfaces* shiny and impunctate on metasternum, feebly punctured, punctulate, or wrinkled on metepisternum and abdomen. *Femora* not toothed. Length 6.7 mm.; breadth 3.6 mm.

VITI LEVU: Holotype, female (BISHOP 2406), Tholo-i-suva, 150 m., Aug. 25, 1938, Zimmerman, taken by beating shrubs.

Differs from *R. dispar* Bryant in being larger, more heavily and less regularly punctured, and more uniformly colored.

23. ***Rhyparida laddi*** Gressitt, n. sp.

FEMALE: Pitchy reddish brown, more reddish on elytron, ventral surfaces and legs, but darker on occiput, pronotum, parts of tibiae, and apices of femora. Body glabrous except for a few minute hairs on ventral surfaces; antenna and legs with some oblique or suberect pale hairs.

Head distinctly narrower than prothorax, about as wide as deep, finely and closely punctured except along median line of occiput behind center. *Antenna* two-thirds as long as body, slender; scape barely thickened, twice as long as second segment; third slightly longer than second; fourth slightly longer than scape, and slightly longer than fifth; sixth and following subequal, each not quite as long as fourth. *Prothorax* one-half as long as broad, not quite three-fourths as broad as elytra, distinctly rounded at side, narrower at apex than at base, broadest slightly behind center; disc moderately convex, finely and irregularly punctured with at least 15 punctures in an approximate mid-longitudinal row; interspaces between punctures somewhat raised, giving an uneven appearance. *Scutellum* longer than broad, rounded apically. *Elytron* nearly three times as long as prothorax, parallel-sided in basal two-thirds, evenly rounded with its fellow apically; disc punctured in about 19 rows at middle, the rows in part regular and in part irregular or unevenly spaced, with extra rows near scutellum and below humerus; disc swollen along hypothetical humeral ridge almost to apex. *Ventral surfaces* apparently impunctate. Length 5.7 mm.; breadth 3.65 mm.

VITI LEVU: Holotype, female (BISHOP 2407), above Matainanu, alt. 125 m., northeast coast of Viti Levu I., June 17, 1928, H. S. Ladd.

Differs from *R. luteola* Fairmaire in being glabrous above, in having the elytral punctures arranged in moderately regular rows and not nearly so dense and numerous, and with the pronotum also much less closely punctured.

24. Rhyparida luteola Fairmaire

Fig. 10*a*

Rhyparida luteola Fairmaire, 1879, Le Naturaliste 1: 75 (Fiji; type in Paris Mus.); 1882 Soc. Ent. de France, Ann. Ser. 6, 1: 434.

Reddish brown, some vague pitchy lines on pronotum; elytron pitchy brown except for reddish base; dorsum with rather close golden brown hairs. Head rugose-punctate; pronotum densely punctured; elytron closely punctured. Length 4.4–6.1 mm.

VITI LEVU: Belt road 32 km. west of Suva, July, Tholo-i-suva, July, Mt. Korombamba, Aug., ridge west of Nandarivatu, Sept. 1938, Zimmerman; Lami, Apr. 1951, Krauss, 28 specimens.

VANUA LEVU: Nakawanga, Oct. 8, 1955, Gressitt, five specimens, on *Couthovia*.

HOST: *Couthovia corynocarpa* A. Gray.

25. *Rhyparida vermiculata* Gressitt, n. sp.

Fig. 10*b*

MALE: Dark castaneous brown, pitchy black on pronotum. Body glabrous above.

Head fully four-fifths as broad as prothorax, as broad as deep, somewhat finely and closely punctured, distinctly striate on occiput. *Antenna* fairly slender, four-fifths as long as body; scape a little longer than second segment; third a little longer than second, subequal to fifth and sixth, shorter than fourth; seventh and following barely longer than fourth. *Prothorax* a little broader than long, a little narrower than elytra, distinctly rounded at side; disc very closely vermiculate-punctate, the anterior portion for most part longitudinally striate-punctate. *Scutellum* a little longer than broad, rounded behind, with a pair of punctures. *Elytron* more than twice as long as prothorax, moderately narrowed posteriorly; disc with 11 regular rows of fairly deep punctures, and two extra scutellar rows; some of basal punctures separated by hardly more than equivalent of their diameters, but much smaller posteriorly. *Metasternum* very sparsely

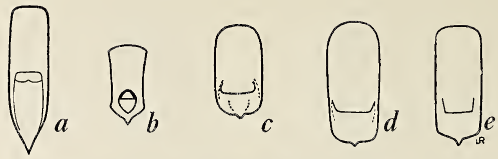

FIG. 10. *a*, *Rhyparida luteola*, aedeagus; *b*, *Rhyparida vermiculata* Gressitt, n. sp., aedeagus; *c*, *Rhyparida kandavu* Gressitt, n. sp., aedeagus; *d*, *Rhyparida strigosa*, aedeagus; *e*, *Rhyparida bryani* Gressitt, n. sp., aedeagus.

punctured; abdomen finely punctured. Length 3.2 mm.; breadth 1.6 mm.

LAU: Holotype, male (BISHOP 2408), Tuvutha I., northern Lau Group, Sept. 11, 1924, Bryan.

Differs from *R. dispar* Bryant in being much smaller, with the pronotum flat and densely vermiculate.

26. *Rhyparida kandavu* Gressitt, n. sp.

Fig. 10*c*

MALE: Pale castaneous brown with basal third of pronotum blackish; ventral surfaces reddish to pitchy; antenna pale in basal half, slightly pitchy in distal half. Pronotum finely pubescent; elytron apparently glabrous.

Head seven-tenths as broad as prothorax, slightly deeper than wide, strongly swollen above, finely and not very closely punctured on frons, strigose-punctate on occiput. *Antenna* two-thirds as long as body, moderately thickened distally; scape a little longer than second segment; third nearly as long as scape, slightly shorter than fourth; fifth as long as fourth, slightly longer than sixth; seventh and following subequal, each thickened distally and barely longer than fifth. *Prothorax* just over three-fourths as long as broad, nearly three-fourths as broad as elytra, distinctly rounded at side, slightly narrower at apex than at base, strongly rounded-convex at anterior margin, obtusely convex at basal margin; disc flattened in central portion which has narrow longitudinal punctures which are narrower than spaces between them; punctures on side of disc mostly rather close and

in obliquely longitudinal grooves. *Scutellum* slightly longer than broad, rounded apically. *Elytron* somewhat convex externally, broadest at middle, evenly curved posteriorly; disc with 11 distinct rows of punctures at middle and an extra scutellar and extra subhumeral row; punctures fairly large near humerus, but much smaller than interspaces along suture and on apical portion. *Ventral surfaces* strongly punctured on metasternum and finely punctured on abdomen. Length 3.1 mm.; breadth 1.3 mm.

PARATYPES: Varying from entirely reddish brown to pitchy black tinged in spots with reddish. Length 2.4–2.9 mm.; breadth 1.2–1.5 mm.

KANDAVU: Holotype, male (BISHOP 2409), Yawi, Apr. 28, 1941, Krauss; allotopotype, female (BISHOP), same data. Nine paratopotypes (BISHOP, BM, USNM, CSIRO), same data. Eleven paratypes, Vambea, Ono I., Kandavu Group, Apr. 30, 1941, Krauss.

Differs from *R. vermiculata* Gressitt in being smaller, in having shorter legs, in having the pronotum partly strigose and partly sparsely punctured, instead of entirely vermiculate, and the elytron with only one extra scutellar row of punctures.

27. ***Rhyparida strigosa*** (Bryant) new comb.
Fig. 10*d*

Nodostoma strigosa Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 424, fig. 6 (Tamavua; type in Brit. Mus.).

Black, metallic; anterior margin of prothorax narrowly fulvous; antenna with first six segments flavous and remainder fulvous; tibiae and tarsi fulvous. *Head* strigose; *antenna* slender, with third to sixth segments subequal; *prothorax* with side rounded basally and slightly contracted in front, strongly but not closely punctured; *elytron* strongly punctate-striate, the punctures stronger than on pronotum; *mesosternum* with a few strong punctures; first abdominal sternite twice as long as second. Length 3 mm.

VITI LEVU: Tamavua (type locality). Six from Bulu, near Sovi, Apr. 21, 1941, Krauss.

One reddish female specimen from Naroi, Moala I. (Aug. 24, 1938, Zimmerman) is close to this species, but probably represents a different race.

28. ***Rhyparida bryani*** Gressitt, n. sp.
Fig. 10*e*

MALE: Pitchy black, somewhat reddish on base and side of elytron, antenna, fore part of head, ventral surfaces, and legs. Pronotum with indistinct fine recumbent hairs; elytron with sparse minute scale and a few minute suberect hairs.

Head just over three-fourths as broad as prothorax, fully as broad as deep, finely and not very closely punctured on frons, somewhat densely substrigose-punctate on occiput, slightly grooved above eye. *Antenna* just over one-half as long as body, moderately stout distally; scape stout, a little longer than second segment and considerably thicker; third subequal to second and fifth, slightly longer than sixth and slightly shorter than fourth; seventh and following about as long as third, but much stouter. *Prothorax* just over three-fourths as long as broad, nearly three-fourths as broad as elytra, distinctly rounded at side, slightly narrower at apex than at base, convex apically and basally; disc convex, deeply impressed with longitudinal punctures which are mostly about as wide as interspaces, with roughly 15 in an approximate mid-longitudinal row. *Scutellum* pentagonal, slightly longer than broad, narrowed from base. *Elytron* just over twice as long as prothorax, subparallel-sided in basal two-thirds; disc deeply punctured in 12 regular rows at middle, with two extra scutellar rows, the interstices somewhat raised, and mostly about as wide as the punctures. *Ventral surfaces* punctured along margin of metasternum and vaguely punctured on abdomen. Length 2.3 mm.; breadth 1.3 mm.

PARATYPES: Sometimes entirely black ex-

cept for antenna and legs. Length 2.1–2.6 mm.; breadth 1.2–1.4 mm.

LAU: Holotype, male (BISHOP 2410), Fulanga I., southern Lau Group, Aug. 5, 1924, E. H. Bryan, Jr.; allotype, female (BISHOP), Ongea I. (Ogea Levu), southern Lau Group, July 21, 1924, Bryan. Four paratypes (BISHOP, BM), Tuvutha I., Sept. 10, and Namuka I., Aug. 12, 1924, Bryan. Named for the collector, who is Curator of Collections at Bishop Museum.

Differs from *R. strigosa* (Bryant) in having the pronotal puncturation much denser, the elytral puncturation somewhat denser, with the interspaces narrower and more raised, with two instead of one extra scutellar row, and with the elytron having fine scales instead of being glabrous.

Genus LABASA Bryant

Labasa Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 592 (type: *L. scutellaris* Bryant; Fiji).

Rather similar to *Rhyparida*, but scutellum highly transverse and angular; head rugose-punctate; pronotum grossly punctured; elytron subcostate basally. Endemic.

29. **Labasa scutellaris** Bryant

Labasa scutellaris Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 592 (Labasa; type in Brit. Mus.).

Pitchy to blackish or ochraceous; mostly dark, with antennal base, parts of legs, and some of basal elytral costae ochraceous; elytral puncture-rows nearly complete, the punctures weaker posteriorly. Length 5–6 mm.

VITI LEVU: Nandarivatu, Navai Mill, Oct. 1937, Valentine; Nandala, Mar. 1941, Degener; Nandarivatu, Aug. 1938, Zimmerman.

VANUA LEVU: Lambasa (type locality). Nakawanga, on *Pipturus*, *Merremia*, and *Trichospermum*, Oct. 8–9, 1955, Gressitt; Nakawanga to Mbangata, Oct. 9, Gressitt.

HOSTS: *Pipturus argenteus* var. *lanosus* Skottsb.; *Merremia peltata* (L.) Merr.; *Trichospermum calyculatum* (Seem.) Burret.

Genus VITIBIA Fairmaire

Vitibia Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 485 (type: *V. rufoviolacea* Fairm.; Fiji).

Antenna more than one-half as long as body, segments subequal except for second. Prothorax much narrower than elytra, quadrate, very narrowly margined. Elytron seriate-punctate basally, the rows disappearing on postmedian portion. Femora unarmed, clavate; tibiae emarginate preapically. Probably some of the following species do not truly belong in this genus.

KEY TO FIJIAN SPECIES OF *Vitibia*

1. Length over 5 mm.; elytra metallic; prothorax red 2
   Length under 4 mm.; elytra testaceous to black; prothorax testaceous to pitchy brown 3

2(1). Elytra metallic green . . . . . . **formosa**
   Elytra violaceous, golden green distally . . . . **rufoviolacea**

3(1). Prothorax about as long as broad, at least in male 4
   Prothorax distinctly broader than long in both sexes 7

4(3). Prothorax dark, metallic; elytron submetallic, greenish to pitchy 5
   Prothorax pale or largely pale; elytron pale to partly brownish 6

5(4). Punctures on center of pronotum almost as large as interspaces, and approximately likewise for elytron; elytron more than one and one-half times as long as broad . . . . **pallipes**
   Punctures on center of pronotum about one-third as large as interspaces, and approximately likewise for elytron; elytron barely one and one-half times as long as broad . . . . **virida**

6(4). Frons and vertex distinctly concave; elytron somewhat carinate and ver-

tical laterally, particularly in female; pronotum generally with a longitudinal dark stripe; elytra darkened posteriorly . . . . **dimorpha**

Frons and vertex flat; elytron not carinate and vertical at side; pronotum and elytron uniformly pale. . . . . **testacea**

7(3). Frontoclypeus almost impunctate, sometimes with one or two large punctures; prothorax narrowed anteriorly, broadest behind middle, or suture darkened; pronotum with punctures of moderate size; testaceous to pitchy with a slight bronzy tinge 8

Frontoclypeus distinctly punctured; prothorax often symmetrical anteroposteriorly, broadest in middle; ochraceous to greenish pitchy 10

8(7). Prothorax broadest slightly behind middle; terminal portion of aedeagus somewhat gradually tapering 9

Prothorax broadest at middle; terminal portion of aedeagus rather suddenly narrowed; body pale with suture darkened . . . . . . **striatipennis**

9(8). About eight punctures in an approximate mid-longitudinal row on pronotum; female without a sharp humeral carina on elytron; male pale; female bronzy brown, darkened on side of elytron, and slightly so on suture . . . . **montana**

About 12 punctures in an approximate mid-longitudinal row on pronotum; female with a sharp humeral carina on elytron; male pale; female dark, often pale only on base and apex of elytron, but sometimes also along middle . . . . **greenwoodi**

10(7). Prothorax evenly rounded at side, widest in middle, symmetrical antero-posteriorly 11

Prothorax not symmetrical anteroposteriorly, widest behind middle. 13

11(10). Pronotal punctures exceedingly fine, separated by spaces several times as wide as punctures 12

Pronotal punctures moderate, separated by spaces often not much greater than width of punctures; pale, with darkened suture . . . . **striatipennis**

12(11). Elytral punctures quite uneven in size, and partly in uneven rows, rarely extending beyond middle; scutellum subpentagonal; aedeagus of male blunt apically . . . . . **vitiensis**

Elytral punctures somewhat even and subregular, often extending beyond middle; scutellum subrounded apically; aedeagus of male acuminate apically . . . . **melochiae**

13(10). Pronotal punctures moderately fine to strong; pronotum not broadest very near base in male; length less than 2.7 mm. 14

Pronotal punctures very minute and very widely spaced; pronotum broadest very near base in male, considerably tapered anteriorly; length more than 2.8 mm.; male ochraceous; female darker along middle of elytral disc . . . . **bryanti**

14(13). Pronotum moderately punctured, less than 10 punctures in an approximate mid-longitudinal row; color pale to partly greenish pitchy 15

Pronotum heavily punctured, at least 12 punctures in an approximate mid-longitudinal row; dorsum pitchy brown to blackish, paler only on front of head and base of elytron, generally darker on pronotum . . . . **rufilabris**

15(14). Pronotal punctures fine, mostly one-third to one-fourth as wide as inter-

spaces; dorsum partly greenish bronzy, at least across center of pronotum and on parts of elytron . . . 16

Pronotal punctures moderate, mostly one-half as wide to nearly as wide as interspaces; dorsum pale except for suture which is sometimes slightly darkened; orifice of aedeagus twice as long as broad . . . **duplicata**

16(15). Largely pale, with slight darkening on pronotum and elytron; elytral punctures not entirely minute behind middle . . . . **obscura obscura**

Largely metallic green, with pale areas on apex and base of pronotum and with a parasutural pale stripe on elytron from base to apex; elytral punctures minute behind middle . . . . **obscura submetallica**

30. Vitibia formosa (Baly)

Fig. 11*a*

Rhyparida formosa Baly, 1877, Ent. Soc. London, Trans. 1877: 40 (New Hebrides; type in Brit. Mus.).

Vitibia formosa Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 485.

Bright ochraceous red, paler on legs and ventral surfaces; elytron metallic green; antenna black beyond fourth segment. Head feebly punctured; prothorax feebly punctured; elytron with rows of moderate punctures which disappear on posterior portion of disc. Length 5–6.2 mm.

VITI LEVU: Londoni, Tailevu, Aug. 1937, Valentine.

OVALAU: Levuka, Nov. 1937, Valentine.

KANDAVU: Yawi, Apr. 1941, Krauss, six specimens.

NEW HEBRIDES.

HOST: On leaf of *Excoecaria agallocha* L., after Lever; *Thespesia populnea* (L.) Sol, after Valentine.

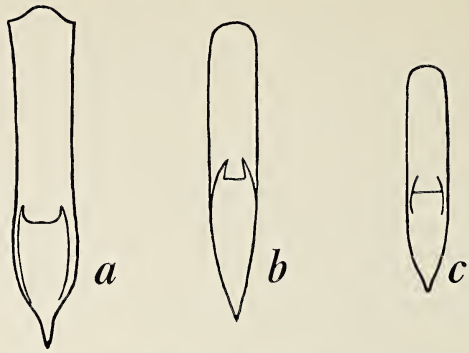

FIG. 11. *a*, *Vitibia formosa*, aedeagus; *b*, *Vitibia montana* Gressitt, n. sp., aedeagus; *c*, *Vitibia greenwoodi*, aedeagus.

31. Vitibia rufoviolacea Fairmaire

Vitibia rufoviolacea Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 485 (Viti; type in Paris Mus.).

Reddish testaceous, shiny; elytra violaceous, metallic greenish apically; antenna brownish with first three and base of fourth testaceous. Prothorax finely and sparsely punctured; elytron finely and irregularly punctured posteriorly. Length 6 mm.

FIJI: Described from "Iles Viti." No material is at hand; possibly this is the same as the preceding.

32. *Vitibia montana* Gressitt, n. sp.

Fig. 11*b*

MALE: Testaceous, slightly darker on suture in basal third; distal portion of last five antennal segments pitchy; parts of thoracic pleura and ventral hind margin of prothorax pitchy brown. Ventral surfaces and legs with a few scattered pale hairs.

Head nearly six-sevenths as broad as prothorax, about as deep as wide, almost impunctate. *Antenna* five-sevenths as long as body; scape one-half again as long as second segment; third as long as second; fourth as long as scape, subequal to fifth and sixth; seventh to last longer, subequal. *Prothorax* nearly seven-eighths as long as broad, just over five-eighths as broad as elytra, somewhat

evenly rounded at side, not much narrower at apex than at base; disc convex, unevenly impressed with punctures of moderate size, coarser at side. *Scutellum* narrow, rounded apically. *Elytron* broadly rounded, widest slightly anterior to middle; disc impressed with about 10 rows of moderate to strong punctures at middle, mostly one-half to one-third as wide as interspaces, but becoming suddenly minute behind basal three-fifths. *Ventral surfaces* punctured along anterior border of metasternum; abdomen minutely rugulose-punctate. Length 2.3 mm.; breadth 1.2 mm.

FEMALE: More reddish, slightly tinged with pitchy along suture and outer margin of elytron, and on metasternum. Length 2.7 mm.; breadth 1.43 mm.

PARATYPES: Length 2.2–2.8 mm.; breadth 1.14–1.5 mm.

VITI LEVU: Holotype, male (BISHOP 2411), Nandarivatu, 1100 m., beating, Sept. 3, 1938, Zimmerman; allotopotype, female (BISHOP), Sept. 5. Eight paratypes (BISHOP, BM, US): five paratopotypes, Sept. 6–10; two Navai-Nasonga trail, 800 m., Sept. 12, 1938, Zimmerman; one Navai Mill, Oct. 13, 1937, Valentine.

Differs from *V. greenwoodi* (Bryant) in being paler, the punctures more regular to behind middle, the elytron not carinate in female, and in the aedeagus tapering gradually to an acute apex instead of narrowing somewhat suddenly before the blunt apex.

33. *Vitibia greenwoodi* (Bryant), n. comb.

Fig. 11*c*

Nodostoma greenwoodi Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 421, fig. 4 (Lautoka; type in Brit. Mus.).

Nitid; head fulvous; prothorax black with anterior margin broadly fulvous; elytron black with base fulvous; antenna and legs flavous. *Head* impunctate; *antenna* slender, with scape twice as long as second segment, and next three slender and subequal; *prothorax* transverse, slightly rounded at side, strongly but not closely punctured; *scutellum* triangular; *elytron* impressed near humerus, strongly punctate-striate, the punctures rather wide apart, the intervals between the striae at side slightly costate. Length 2.5 mm.

VITI LEVU: Lautoka (type locality). Twelve, Navai-Nasonga trail, 800 m., Sept. 12, 1938, Zimmerman; two, Navai Mill, Nandarivatu, Oct. 13, 1937, Valentine.

OVALAU: One, Andubangda, 450 m., July 15, 1938, Zimmerman.

34. *Vitibia striatipennis* Bryant, n. sp.

Fig. 12*a*, *b*

Flavous, seven apical segments of antenna fuscous; elytron with suture and side margin narrowly black, and from shoulder a faint fuscous stria parallel with side margin.

Head flavous, impunctate, a short longitudinal impression between bases of antennae, eye large and prominent. *Antenna* long and slender, extending to middle of elytron; first segment longest and more dilated, about twice as long as second; seven apical segments tinged with fuscous. *Prothorax* flavous, somewhat nitid, with large scattered punctures; side rounded; very slightly broader than long. *Scutellum* triangular, impunctate, fuscous. *Elytron* elongate, rounded at apex, flavous; suture and side margin narrowly black, and from shoulder a faint fuscous stria running parallel to side margin; punctate-striate, the punctures large and widely spaced. *Legs* flavous, middle and posterior pair emarginate at apex of tibia. *Underside* flavous, ventral segments of abdomen with scattered golden pubescence. Length 2.4 mm.; breadth 1.1 mm.

VITI LEVU: Holotype (BISHOP 2412), Nandarivatu, Tholo North, Oct. 18, 1937, Valentine; two specimens. Nandarivatu, 1100 m., Sept. 6, and ridge west of Nandarivatu, 800 m., Sept. 11, 1938, Zimmerman; two specimens. One, Lautoka, Mar. 1955, Krauss.

A very distinct species, its elongate shape somewhat allied to *V. pallipes* Bry.

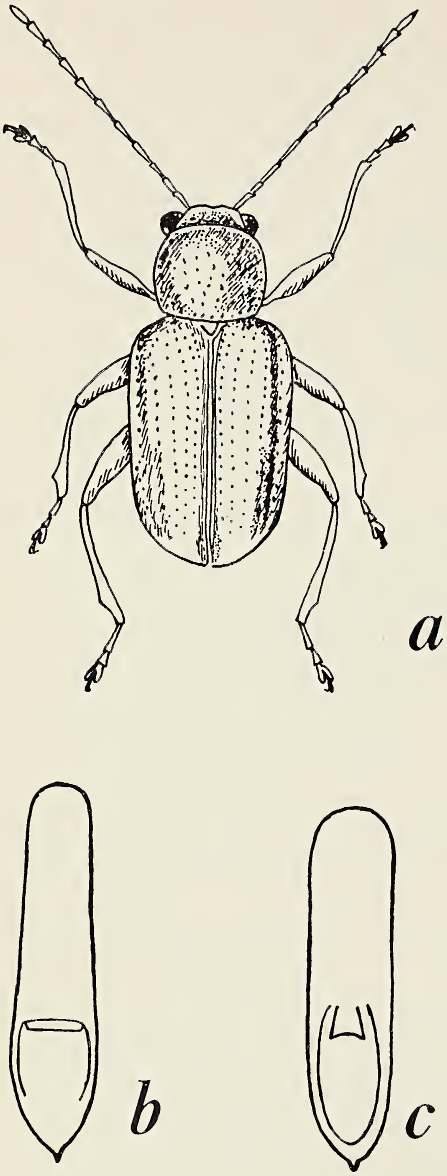

FIG. 12. *a*, *Vitibia striatipennis* Bryant, n. sp., adult; *b*, *Vitibia striatipennis*, aedeagus; *c*, *Vitibia vitiensis*, aedeagus.

35. ***Vitibia vitiensis*** (Bryant), n. comb.
Fig. 12*c*

Nodostoma vitiensis Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 512 (Taveuni, Suva; type in Brit. Mus.).

Fulvous; apical half each of last five antennal segments fuscous; elytron entirely fulvous or with varying degrees of black markings, which do not reach humerus or apex. *Head* impunctate; *antenna* with scape longer and more swollen than second segment, second to sixth slender and subequal, and seventh to last thicker and subequal; *prothorax* slightly transverse, rounded at side, with a few irregular punctures; *scutellum* triangular; *elytron* with basal half strongly but irregularly punctured in irregular striae, and apical half nearly impunctate; *abdominal sternites* finely punctured. Length 3 mm.

VITI LEVU: Suva. One, Tholo-i-suva, 150 m., July 25, 1938, Zimmerman; one, Nayavu, Mar. 1951, Krauss.

TAVEUNI: (Type locality.)

MOALA: July 13, 1924, Bryan.

LAU: Vanua Mbalavu I., Sept. 23, 1924, Bryan; Mvava, Vanua Mbalavu, at seashore, Aug. 9, 1938, Zimmerman; Munia I., Aug. 3, 1938, Zimmerman; Mothe I., Aug. 14–16, 1924, Bryan.

HOST: *Gossypium* (cotton).

36. ***Vitibia melochiae*** Gressitt, n. sp.
Fig. 13*a*, *b*

MALE: Pale testaceous, slightly reddish behind eye and on mouth parts. Ventral surfaces and legs with sparse fine pale hairs.

Head nine-tenths as broad as prothorax, about as wide as deep, moderately punctured in middle; occiput finely grooved anteriorly, nearly impunctate. *Antenna* slender, three-fourths as long as body; scape nearly one-half again as long as second segment, subequal to third, fourth, and fifth; sixth slightly longer; seventh to last subequal, each slightly longer than sixth. *Prothorax* nearly six-sevenths as long as broad, two-thirds as broad as elytra, subevenly rounded at side, narrower at apex than at base, widest slightly behind middle; disc subfinely and unevenly punctured, most of punctures about one-third as large as interspaces. *Scutellum* as long as broad, obtuse

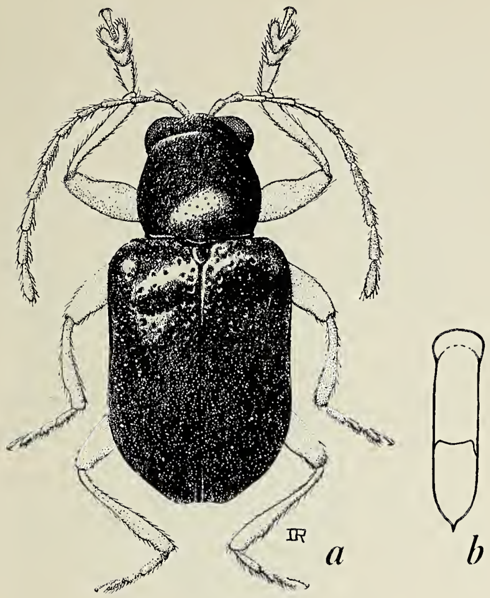

FIG. 13. *a*, *Vitibia melochiae* Gressitt, n. sp., type; *b*, *Vitibia melochiae*, aedeagus.

apically. *Elytron* subparallel-sided in basal two-thirds; disc subregularly punctured in about nine rows, the punctures irregular in size, mostly about two-thirds as wide as interspaces, much smaller in apical third. *Ventral surfaces* nearly impunctate. Length 2.3 mm.; breadth 1.15 mm.

FEMALE: Abdomen pitchy on first four segments. Length 2.6 mm.; breadth 1.4 mm.

PARATYPES: Length 2.3–2.6 mm.; breadth 1.3–1.6 mm.

VANUA LEVU: Holotype, male (BISHOP 2413), Nakawanga, 75 m., on *Melochia*, Oct. 8, 1955, Gressitt; allotopotype, female (BISHOP), same data; 22 paratopotypes, (BISHOP, BM, US, CSIRO, CAS), same data.

VITI LEVU: Two, Korovou, Tailevu, Sept. 20, 1937, Valentine; one, Mt. Victoria, 900 m., Sept. 16, 1938, Zimmerman; one, Nandarivatu, 1100 m., Sept. 6, 1938, Zimmerman; one, Tholo-i-suva (Colo-i-suva), June 21, 1924, Bryan; one, Lautoka, Mar. 1955, Krauss.

KANDAVU: One, Drue, Apr. 20, 1941, Krauss.

HOST: *Melochia vitiensis* A. Gray.

Differs from *V. vitiensis* (Bryant) in being slightly smaller, paler, with the pronotal punctures slightly finer, the elytral punctures more regular and continuing farther posteriorly, and the aedeagus more suddenly narrowed before apex.

37. *Vitibia duplicata* Gressitt, n. sp.

Fig. 14*a*

MALE: Ochraceous, hyaline; legs and antenna testaceous, latter with apices of distal segments slightly darkened. Ventral surfaces and appendages with sparse pale suberect hairs.

Head nine-tenths as broad as prothorax, as wide as deep, moderately punctured at middle; occiput finely grooved anteriorly and minutely punctured; gena short. *Antenna* nearly five-sixths as long as body; scape one-third again as long as second segment; third subequal in length to second, distinctly shorter than fourth; fourth to sixth subequal; seventh and following slightly longer, subequal. *Prothorax* six-sevenths as long as broad, just over seven-tenths as broad as elytra, rounded at side, distinctly narrowed anteriorly, widest well behind middle; disc convex, irregularly punctured, the interspaces one to three times as wide as punctures. *Scutellum* short, rounded

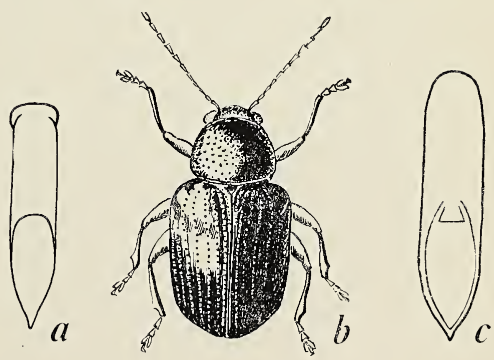

FIG. 14. *a*, *Vitibia duplicata* Gressitt, n. sp., aedeagus: *b*, *Vitibia rufilabris* Bryant, n. sp., type; *c*, *Vitibia rufilabris*, aedeagus.

behind. *Elytron* narrow, subparallel in basal two-thirds; disc punctured in about nine rows, the punctures unequal in size, interspaces from one to three times as wide as punctures, which disappear in apical third. *Ventral surfaces* and appendages with sparse suberect pale hairs. Length 2.3 mm.; breadth 1.1 mm.

PARATYPES: Some slightly reddish, or slightly darkened along suture. Length 2.25–2.5 mm.; breadth 1.1–1.28 mm.

VITI LEVU: Holotype, male (BISHOP 2414), Tholo-i-suva (Colo-i-suva), June 21, 1924, E. H. Bryan, Jr. Four paratypes: Nandarivatu, 1100 m., Sept. 3, Navai-Nasonga trail, west slope, 800 m., Sept. 12, 1938, Zimmerman, and Mt. Victoria, 1100 m., Sept. 10, 1938, Kondo.

Differs from *V. vitiensis* (Bryant) in having the pronotum more narrowed anteriorly more heavily punctured, the elytron punctured farther posteriorly, and the aedeagus being more gradually narrowed and acuminate apically.

38. *Vitibia rufilabris* Bryant, n. sp.

Fig. 14*b*, *c*

Shining black; labrum, base of antenna, and legs more or less rufous. Prothorax strongly punctured; elytron more finely punctate-striate.

Head and labrum more or less rufous, a few very strong punctures between bases of antennae; basal portion of head impunctate. *Antenna* extending to middle of elytron; basal segments rufous; five apical segments fuscous, each with basal portion fulvous. *Prothorax* shining black strongly punctured; side rounded. *Scutellum* black, nitid, triangular, impunctate. *Elytron* shining black, wider than base of prothorax, sides parallel and rounded to the apex, more finely punctate-striate, becoming almost impunctate towards apex. *Legs* more or less rufous, tarsi paler, middle and posterior tibiae emarginate near apex. *Underside* with the ventral segments of the abdomen fulvous and impunctate. Length 3 mm.

VITI LEVU: Holotype (BISHOP 2415), Nandarivatu, 600 m., Sept. 1, 1938, Zimmerman. Three paratypes: Nandarivatu, Sept. 5, Zimmerman; Nandarivatu, Oct. 18, 1937, Valentine; ridge west of Nandarivatu, 800 m., Sept. 9, 1938, Zimmerman.

Somewhat similar to *R. strigosa* (Bryant), but with no trace of pubescence, and the puncturation of the prothorax much stronger, and the punctate-striae of the elytron much finer.

39. *Vitibia obscura obscura* Gressitt, n. sp.

Fig. 15*a*, *b*

Dull testaceous to bronzy pitchy, in part paler; head bronzy pitchy, paler on frons; antenna pitchy brown, testaceous on first four segments; pronotum bronzy pitchy, somewhat paler basally and on anterior margin; elytron dull brown, paler behind humerus, darker on margin and blackish along suture; ventral surfaces reddish brown, darker on metasternum; legs testaceous. Antenna, legs, and distal portion of abdomen moderately clothed with oblique goldish hairs.

Head with a few deep punctures on frons and vertex, and a few medially on anterior portion of occiput; eye rounded oval. *Antenna* three-fourths as long as body, slender; first six segments subequal in length except second a little shorter; seventh and following segments longer; last appendiculate. *Prothorax* very slightly broader than long, nearly as broad at apex as at base, moderately and evenly rounded at side; disc rather heavily punctured, the punctures mostly a little smaller than spaces between them. *Scutellum* convex, tapering. *Elytron* subparallel-sided, tapering from end of third fifth; disc with rows of deep punctures which are mostly nearly as large as interspaces; discal rows disappearing on apical declivity. *Ventral surfaces* feebly punctured. Length 2.2 mm.; breadth 1 mm.

PARATYPES: Length 2.1–2.3 mm.; breadth 1–1.2 mm.

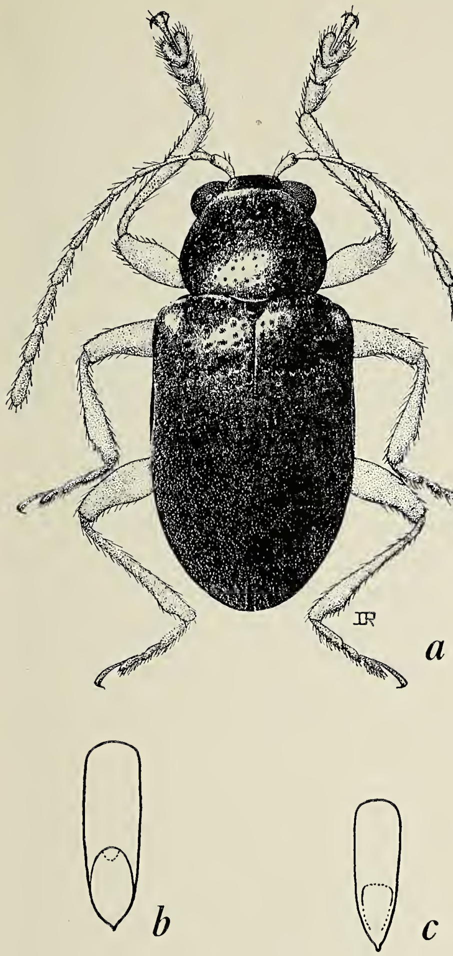

FIG. 15. *a*, *Vitibia obscura obscura* Gressitt, n. sp., type; *b*, *Vitibia obscura obscura*, aedeagus; *c*, *Vitibia obscura submetallica* Gressitt, n. subsp., aedeagus.

VITI LEVU: Holotype (BISHOP 2416), Navai-Nasonga trail, 1000 m., Sept. 12, 1938, Zimmerman; two paratopotypes, same data; four paratypes (one in BM) Nandarivatu, Sept. 2 and 5, and ridge west of Nandarivatu, Sept. 11, 1938, Zimmerman.

Differs from *V. vitiensis* Bryant in being smaller, darker, partly metallic, with much heavier puncturation.

40. *Vitibia obscura submetallica* Gressitt, n. subsp.

Fig. 15*c*

FEMALE: Bronzy black, or pitchy to testaceous; head reddish anteriorly, bronzy black behind; antenna reddish tinged with pitchy; prothorax bronzy blackish, but bronzy testaceous on anterior and posterior borders and along median line; scutellum pitchy; elytron blackish bronzy, testaceous along basal half of suture and on apex; ventral surfaces blackish, becoming brownish towards apex of abdomen; legs testaceous.

Head with a few distinct punctures anteriorly, finely and sparsely punctured on occiput. *Antenna* three-fourths as long as body; first two segments swollen, first one-half again as long as second; third to sixth slender, subequal, each about as long as scape; seventh to last stouter and longer. *Prothorax* four-fifths as long as broad, not distinctly margined laterally, moderately punctured, the punctures mostly one-third or less as large as spaces between them. *Scutellum* narrowed and rounded behind. *Elytron* moderately punctured in regular rows, the punctures mostly smaller than interspaces, and disappearing at beginning of apical third. *Ventral surfaces* feebly punctured. Length 2.8 mm.; breadth 1.6 mm.

VANUA LEVU: Holotype, female (BISHOP 2417), Nakawanga, Oct. 8, 1955, Gressitt; allotype, male, and one paratype, female, same data. Another female, same data, entirely green, somewhat questionably this species.

The coloration varies from almost entirely blackish green, except for antenna and legs, to bronzy ochraceous with sides of prothorax and elytron, and suture, darker.

Differs from *V. obscura* in being darker and more metallic, and in having the pronotum more finely punctured, and the elytron with punctures lacking posteriorly.

41. ***Vitibia bryanti*** Gressitt, new name
Fig. 16*a*

Vitibia vitiensis Bryant, 1945 (*nec Nodostoma vitiensis* Bryant, 1942), Ann. and Mag. Nat. Hist. Ser. 11, 12: 424, fig. 7 (Fiji; type in Brit. Mus.).

Reddish ochraceous, paler on antenna, legs and abdomen. *Head* impunctate except on frons and middle of vertex; *prothorax* nearly impunctate, distinctly rounded at side; *elytron* with very short basal rows of punctures and only sutural and marginal row continuing to apex. Length 2.9–3.3 mm.

VITI LEVU: Tholo-i-suva, Aug., Mt. Victoria (type loc.), Sept. 1938, Zimmerman, nine specimens, at 150–1200 m.; also Lever.

HOST: *Agapetes vitiensis* leaf, at 1300 m.; Lever.

42. ***Vitibia testacea*** Gressitt, n. sp.
Fig. 16*b*

MALE: Ochraceous, subhyaline; slightly dull on parts of head and antenna. Ventral surfaces and appendages with sparse pale hairs.

Head seven-eighths as broad as prothorax, not quite as wide as deep, deeply punctured in middle; occiput feebly grooved anteriorly, indistinctly punctured. *Antenna* five-sixths as long as body, rather slender; scape one-fourth longer than second segment; third slightly longer than second; fourth longer than third, subequal to fifth; sixth slightly shorter; seventh to last longer, subequal. *Prothorax* seven-eighths as long as broad, more than five-eighths as broad as elytra, subevenly rounded at side, hardly narrower at apex than at base; disc feebly convex on central portion, with irregularly arranged punctures of varying sizes, mostly fairly strong, but smaller than interspaces, about eight in an approximate median line. *Scutellum* narrow, rounded-subacute apically. *Elytron* barely more than twice as long as prothorax, subparallel in basal two-thirds; disc convex, with a subbasal swelling,

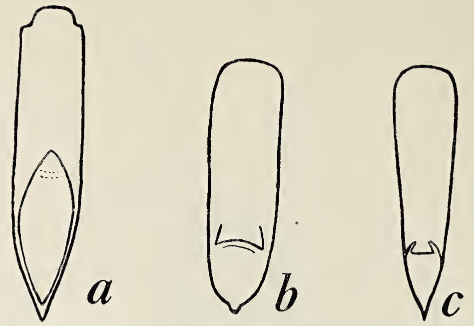

FIG. 16. *a*, *Vitibia bryanti* Gressitt, n. n., aedeagus; *b*, *Vitibia testacea* Gressitt, n. sp., aedeagus; *c*, *Vitibia virida* Gressitt, n. sp., aedeagus.

incompletely punctured in 11 rows at middle, the punctures varying in size from larger to much smaller than interspaces, and disappearing in apical third. *Ventral surfaces* impunctate on metasternum, finely punctured on abdomen. Length 2.8 mm.; breadth 1.3 mm.

PARATYPES: Length 2.6–3.3 mm.; breadth 1.2–1.4 mm.

VITI LEVU: Holotype, male (BISHOP 2418), Nandarivatu, 1100 m., Sept. 6, 1938, Zimmerman. Two paratopotypes, Sept. 10, 1938, Zimmerman. Another, Mt. Victoria, 900 m., Sept. 16, 1938, Zimmerman, has the prothorax shorter and more coarsely punctured.

OVALAU: One, Andubangda, 400 m., July 15, 1938, Zimmerman.

Differs from *V. bryanti* Gressitt in being smaller, narrower, with the prothorax more rounded at side, less narrowed anteriorly, and more heavily punctured, and the elytron paler and a little more heavily punctured.

43. ***Vitibia virida*** Gressitt, n. sp.
Fig. 16*c*

MALE: Metallic green above, tinged in part with pitchy reddish on head and humerus; ventral surfaces pitchy on hind thorax, becoming testaceous towards end of abdomen; antenna dull reddish; legs testaceous with

distal portions of fore femur pitchy. Abdomen, legs, and antenna with sparse suberect pale hairs.

Head nearly six-sevenths as broad as prothorax, about as wide as deep, moderately punctured in center; occiput finely grooved and hardly punctured. *Antenna* slender, four-fifths as long as body; scape two-thirds again as long as second segment; third a little longer than second, distinctly shorter than fourth; fifth equal to fourth, slightly longer than sixth; seventh to last longer, stouter, subequal. *Prothorax* slightly longer than broad, nearly two-thirds as broad as elytra, evenly rounded at side, widest at middle, barely narrower at apex than at base; disc convex, subevenly punctured, the punctures mostly about one-third as large as interspaces in center, and larger and closer at side. *Scutellum* small, rounded at side and obtuse apically. *Elytron* slightly more than twice as long as prothorax, slightly broadened behind middle, where it is somewhat inflated at top of lateral declivity; disc convex, somewhat regularly punctured in nine rows at middle, the punctures mostly about one-half as wide as interspaces, and suddenly becoming minute at end of second third. *Abdomen* feebly rugulose-punctate. Length 2.5 mm.; breadth 1.13 mm.

FEMALE: Length 2.4 mm.; breadth 1.34 mm.

VITI LEVU: Holotype, male (BISHOP 2419), Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman; allotype, female, Lami Quarry, near Suva, May 1951, Krauss. Three paratypes: Nandarivatu, Sept. 10, 1938, Zimmerman, Lami Quarry, May 1951 and Mar. 1955, Krauss.

Differs from *V. obscura submetallica* Gressitt in being almost uniformly metallic greenish above, in having the prothorax longer, symmetrical antero-posteriorly, and the aedeagus with terminal orifice proportionately shorter in relation to distance to bend, and apex a little more acuminate.

44. *Vitibia dimorpha* Gressitt, n. sp.
Fig. 17*a*, *b*

FEMALE: Pale ochraceous, marked with pitchy brown; head testaceous; antenna testaceous on first three segments, remainder pitchy with bases reddish; prothorax pale ochraceous with median line broadly pitchy, the line slightly broadened at middle; elytron pitchy reddish brown with a slight bronzy tinge, pale ochraceous on extreme base, testaceous on humeral ridge from behind humerus nearly to middle; ventral surfaces testaceous, duller at side of abdomen; legs testaceous. Legs and ventral surfaces sparingly clothed with short oblique goldish hairs; denser hairs on antenna.

Head sparsely and distinctly punctured on frons and vertex, slightly grooved on occiput; frons as deep as wide between antennal insertions. *Antenna* fully three-fourths as long as body, slender; first six segments subequal in length except second and third slightly shorter; seventh and following longer and slightly

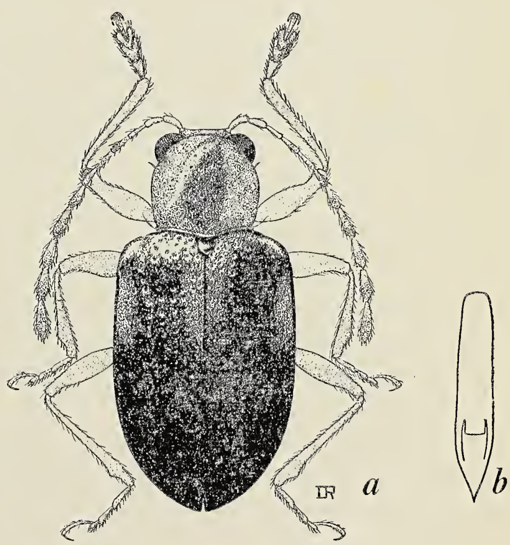

FIG. 17. *a*, *Vitibia dimorpha* Gressitt, n. sp., type; *b*, *Vitibia dimorpha*, aedeagus.

thicker; last appendiculate. *Prothorax* nearly as long as broad, almost as broad apically as basally, evenly rounded at side, distinctly rounded in outline of anterior margin; disc with deep punctures mostly separated by twice their diameters. *Scutellum* trapeziform, rounded behind. *Elytron* slightly broadened to just behind middle, then narrowed, distinctly carinate from humerus to middle; disc with regular rows of deep punctures, mostly as large as interspaces, the punctures suddenly becoming obsolete at end of third fifth, except for two outer rows and sutural row. *Ventral surfaces* feebly punctured. Length 2.65 mm.; breadth 1.35 mm.

MALE: Elytron not distinctly carinate behind humerus. Length 2.25 mm.; breadth 0.92 mm.

PARATYPES: Length 2.1–2.95 mm.; breadth 0.85–1.4 mm.

VITI LEVU: Holotype, female (BISHOP 2420), forest near Samabula, near Suva, Feb. 6, 1952, Gressitt, possibly on *Commersonia*; allotopotype, male (BISHOP), same data; eight paratopotypes (BISHOP, BM, USNM, CSIRO), same data. One female (BISHOP), Lami Quarry, near Suva, May 1951, Krauss. One male, Mt. Korombamba, 400 m., Aug. 1, 1938, Zimmerman.

Differs from *V. bryanti* Gressitt in being smaller, with dark and pale contrasted markings, with much heavier puncturation, and with the elytron carinate behind humerus in female.

45. *Vitibia pallipes* Bryant, n. sp.
Fig. 18

Narrowly elongate, metallic greenish black, legs long and slender; flavous, prothorax strongly but not closely punctured; elytron punctate-striate.

Head impunctate, frontal half flavous, basal half greenish black and nitid. *Antenna* long and slender, extending beyond middle of elytron; four basal segments fulvous, remainder black; two basal segments thickened; first twice as long as second. *Prothorax* shining, greenish black, about as broad as long; side slightly rounded, strongly but not closely punctured. *Scutellum* greenish black, triangular, nitid and impunctate. *Elytron* greenish black, wider than base of prothorax, elongate, sides parallel, rounded at apex, strongly punctate-striate, less so towards apex. *Legs* flavous, long and slender, middle and posterior tibiae emarginate near apex. *Underside* entirely flavous. Length 2.5 mm.

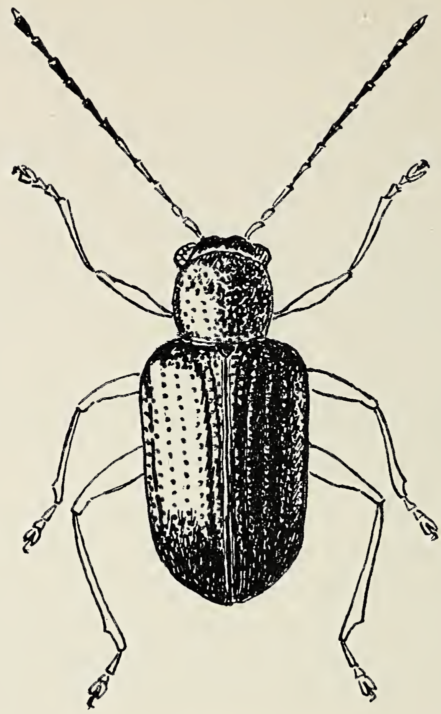

FIG. 18. *Vitibia pallipes* Bryant, n. sp.

VITI LEVU: Holotype, female (BISHOP 2421), Mt. Victoria, west slope, 1000 m., Tholo North, beating, Sept. 13, 1938, Zimmerman; one specimen.

Somewhat allied to *V. bryanti* Gressitt, but the color different, more elongate and narrower, and more strongly punctured.

Genus STYGNOBIA Weise

Stygnobia Weise, 1922, Arch. f. Naturgesch. 88 A (10): 154 (type: *S. cauta* Weise; Samoa).

Ovate, compact; eye small; antenna slender, flattened distally; prothorax transverse, nearly as broad as elytral base; elytron irregularly punctured; dorsum pubescent; middle tibia emarginate preapically; hind tibia hardly emarginate; claws bifid.

Except for Fiji, this genus has been recorded only from Samoa. The Fijian species are rather dissimilar in size and appearance from the type of the genus, but some of the Samoan species seem to be intermediate. The Fijian species resemble *Trichostola* in appearance, and in some characters, but probably belong more properly in *Stygnobia*.

KEY TO FIJIAN SPECIES OF *Stygnobia*

1. Body largely reddish or purplish brown to slightly metallic 2
   Body generally metallic greenish or bluish 4

2(1). Reddish brown, rarely almost pitchy; prothorax nearly as broad as elytra, closely punctured, but not subrugose; length 2 mm. 3
   Purplish brown to pitchy; prothorax narrower than elytra, very densely punctured; length 3 mm. . . . . **evansi**

3(2). Dorsum generally with golden pubescence, which is fairly brief on pronotum; central and basal portions of pronotal disc with interpunctural areas raised, almost ridge-like, and the punctures somewhat in rows converging towards center of base. . . . . **oconnori**
   Dorsum with white pubescence, which is rather long on pronotum and side of middle of elytron; central and basal portions of pronotal disc with interpunctural areas fairly flat, and the punctures somewhat in longitudinal rows which do not converge. . **albiseta**

4(1). Prothorax rather distinctly margined at side 5
   Prothorax somewhat feebly margined at side, very closely punctured; elytron a little less densely punctured; blackish to greenish or bluish; length 2–2.4 mm. . . . . **metallica**

5(4). Length less than 2.5 mm. 6
   Length more than 2.5 mm.; purplish bronzy above, with silvery to golden pubescence; legs, including femora, generally reddish . . . . **elliptica**

6(5). Elytron somewhat vertical at side, more or less ridged behind humerus; pronotum very densely punctured 7
   Elytron almost evenly declivitous at side, hardly ridged behind humerus; prothorax distinctly narrowed and declivitous anteriorly at side; pronotum rather finely punctured; body length less than 2 mm. . . . . **nandarivatu**

7(6). Prothorax about as broad as elytra, rather distinctly pubescent; dorsum generally green to golden green. . . . . **leveri**
   Prothorax slightly narrower than elytra, feebly pubescent; dorsum generally bronzy . . . . **ovalaua**

46. ***Stygnobia evansi*** (Bryant) n. comb.

Trichostola evansi Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 510 (Bucalevu; type in Brit. Mus.).

Metallic with a purple tinge above, black beneath; clothed with fine gray pubescence; six basal antennal segments flavous; tibiae and tarsi fulvous. *Head* finely punctured, a transverse impression between eyes; *antenna* slender, third to sixth segments slender and subequal, last longest and acuminate; *prothorax* transverse, rounded at side, strongly and evenly punctured, clothed with fine pubescence; elytron parallel-sided, rounded apically, strongly and evenly punctured, clothed with fine gray pubescence, a slight depression below humerus. Length 2.5 mm.

VITI LEVU: Naivithula, Tailevu, Sept. 1937, Valentine; Nandarivatu, Sept., Tholo-i-suva and Belt road 25 km. west of Suva, July 1938,

Zimmerman; Suva, Feb. 1952, Gressitt; Raki Raki, Jan. 1955, Lami, Mar. 1951, Krauss. Thirty-seven specimens.

OVALAU: Andubangda and Draiba trail July 1938, Zimmerman.

TAVEUNI: Buthalevu.

LAU: Avea, Sept. 1924, Bryan.

47. ***Stygnobia oconnori*** Gressitt, n. sp.
Fig. 19*a*

Reddish ochraceous brown, slightly tinged with bronze above, paler ochraceous beneath and on appendages. Dorsum distinctly clothed with posteriorly curved silvery white hairs, part of which appear somewhat golden in certain lights.

Head two-thirds as broad as prothorax, moderately punctured, more densely so on posterior portion of occiput, and postocciput. *Antenna* nearly three-fourths as long as body, not very stout, gradually thickened from third segment; third segment barely as long as second, subequal to next two; remainder slightly longer. *Prothorax* more than four-fifths as long as broad, distinctly rounded at side, widest just behind middle, distinctly narrower apically than basally, slightly narrower than elytra; disc deeply, closely, and subrugosely punctured, the punctures partly sublongitudinal, or arranged longitudinally, in central portion. *Scutellum* small, narrow, narrowed and subrounded behind. *Elytron* short, subparallel in basal two-thirds, strongly convex, deeply and closely, and only in part subseriately punctured on basal half, much more finely and sparsely punctured on posterior half. *Ventral surfaces* deeply punctured in a few rows on metasternum, somewhat rugose on abdomen. Length 1.76 mm.; breadth 1.06 mm.

PARATYPES: Length 1.65–2.2 mm.; breadth 1–1.2 mm.

OVALAU: Holotype (BISHOP 2425), Andubangda, 400 m., beating, July 15, 1938, Zimmerman.

VITI LEVU: Nandarivatu, 1100 m., Sept. 3, Mt. Victoria, 1000 m., Sept. 13, Tholo-i-suva,

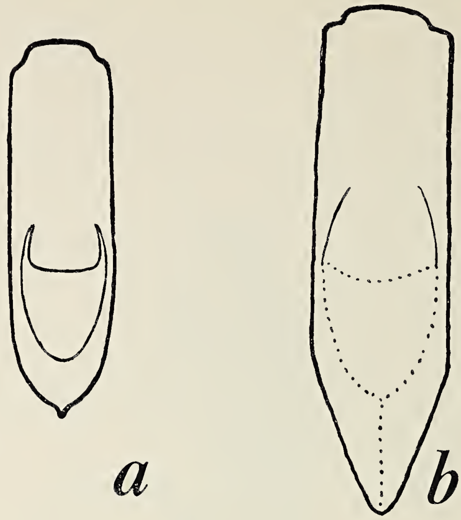

FIG. 19. *a*, *Stygnobia oconnori* Gressitt, n. sp., aedeagus; *b*, *Stygnobia albiseta* Gressitt, n. sp., aedeagus.

150 m., July 21, Navai-Nasonga trail, 1000 m., Sept. 12, 1938, Zimmerman. Natubakula, near Singatoka, Apr. 19, 1941; Lami Quarry, near Suva, May 1951, Krauss; Tholo-i-suva, Apr. 1951, Krauss.

VANUA LEVU: Nakawanga, 75 m., Oct. 9, 1955, Gressitt.

LAU: Buthalevu, 75 m., Aug. 10, Mbavatu, Aug. 16, 1938, Vanua Mbalavu I., Zimmerman.

A total of 19 paratypes.

Differs from *S. evansi* (Bryant) in being much shorter, paler, less purplish, less rugose, less regularly punctured, and with the prothorax relatively broader. Named for B. A. O'Connor, Senior Entomologist, Fiji, as a token of appreciation for kindnesses tendered.

48. ***Stygnobia albiseta*** Gressitt, n. sp.
Fig. 19*b*

MALE: Reddish brown; testaceous on front of head, antenna, and legs; head and pronotum very slightly bronzy. Body clothed above with fairly long, arched, whitish hairs, which are particularly long on pronotum and side of elytron; ventral surfaces more sparsely and briefly clothed with less whitish hairs.

Head deeply and somewhat closely punctured, flat on frons, slightly concave on anterior portion of occiput, grooved above eye. *Antenna* two-thirds as long as body, most segments thickened preapically; scape a little longer than second; third more slender than second, subequal in length; fourth slender, subequal to third; fifth longer; sixth and following stouter. *Prothorax* as broad as elytral bases, rounded at side, not quite three-fourths as long as broad; disc evenly convex, deeply punctured, the punctures closer than interspaces. *Scutellum* narrowed and rounded, slightly punctured. *Elytron* fully twice as long as prothorax, broadest near middle, strongly convex, deeply, closely, and in part subseriately punctured. *Ventral surfaces* deeply punctured on metasternum, feebly punctured on abdomen. Length 2.14 mm.; breadth 1.28 mm.

PARATYPES: Length 1.8–2 mm.; breadth 1.1–1.2 mm.

CENTRAL FIJI: Holotype, male (BISHOP 2454) Naroi, 300 m., Moala I., Aug. 24, 1938, beating shrubs, Zimmerman. Three paratopotypes (BISHOP, BM), same data.

Differs from *S. oconnori* Gressitt in having whiter and longer hairs, particularly on the pronotum, and in having the pronotal interspaces fairly flat, not ridge-like, and with the punctures on mid-basal portion of pronotum in parallel longitudinal rows, instead of converging rows.

49. Stygnobia metallica Bryant

Stygnobia metallica Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 425, fig. 8 (Taveuni; type in Brit. Mus.).

Dark metallic green, clothed with gray pubescence; antenna flavous with last two segments fuscous; fore and mid tibia flavous, each with basal third dark green; hind tibia flavous with basal half dark green. *Head* strongly but not closely punctured, frons almost impunctate; *antenna* slender, reaching middle of elytron, with first segment slightly longer than second, third subequal to second, fourth longer than third; *prothorax* strongly and closely punctured, widest at base, and side contracted anteriorly from middle and feebly margined; *scutellum* subquadrate; *elytron* irregularly punctate-striate, side tapering from behind middle to apex; meso- and metasterna strongly punctured; abdominal sternites more finely punctured and pubescent. Length 2.35 mm.

VITI LEVU: Nandarivatu, 950 m., Sept., Navai Mill, Sept. 17, Tholo-i-suva, July 27, 1938, Zimmerman. Lami Quarry, near Suva, May 1951, Krauss.

OVALAU: Andubangda, 300–450 m., Aug. 18, 1938, Zimmerman.

VANUA LEVU: Nakawanga, 75 m., Oct. 8, 1955, Gressitt.

TAVEUNI: Type locality (Crater Lake).

50. *Stygnobia elliptica* Gressitt, n. sp.

Fig. 20*a*, *b*

Bronzy with a purplish tinge above; scutellum greenish; venter pitchy tinged with purplish or bluish; appendages reddish ochraceous, slightly darker on apex of hind femur and somewhat pitchy brown on distal three-fifths of antenna. Dorsum distinctly clothed with curved, oblique golden hairs, appearing silvery in certain lights, particularly towards side.

Head five-eighths as broad as prothorax, subvertical and almost plane in front, moderately punctured, more heavily so on occiput, nearly ridged on postocciput. *Antenna* three-fifths as long as body, subcylindrical, narrowed in third to sixth segments; second to seventh segments subequal in length. *Prothorax* five-sevenths as long as broad, practically as broad as elytra, moderately narrowed and declivitous anteriorly at side; disc heavily, but not very deeply, punctured, the punctures for most part distinctly wider than interspaces. *Scutellum* subsquarish, obtuse behind. *Elytron* fully twice as long as prothorax, somewhat vertical at side, convex above, rather closely and irregularly punctured, the punctures form-

ing somewhat oblique longitudinal lines on central portion, mostly about as broad as interspaces on basal half, much finer posteriorly. *Ventral surfaces* deeply punctured on metasternum, more finely punctured on remainder. Length 2.7 mm.; breadth 1.5 mm.

VITI LEVU: Holotype (BISHOP 2426), Nandarivatu, 1100 m., beating shrubbery, Sept. 10, 1938, Zimmerman. Four paratypes (BISHOP, BM): Nandarivatu, Sept. 6–10, Mt. Korombamba, 400 m., Aug. 1, and Tholo-i-suva, 150 m., July 25, 1938, Zimmerman.

Differs from *S. leveri* (Bryant) in being longer, more bronzy, with more golden pubescence, and in closer pronotal puncturation.

51. *Stygnobia nandarivatu* Gressitt, n. sp.

Fig. 20*c*

Metallic green, with a slightly golden tinge, above; purplish pitchy beneath; antenna testaceous, becoming slightly pitchy beyond middle; legs testaceous. Dorsum distinctly clothed with posteriorly arched silvery white hairs, in some lights appearing slightly golden.

Head four-sevenths as broad as prothorax, rather broad and flat between antennal insertions and eyes, sparsely punctured, a little more coarsely punctured towards postocciput. *Antenna* three-fourths as long as body; first two and last five segments moderately thickened; scape distinctly longer than second segment; third about as long as second, slightly shorter than fourth; fourth to sixth subequal; seventh and following slightly longer. *Prothorax* four-sevenths as long as broad, as broad as elytral base, distinctly narrowed and declivitous at side, anteriorly; rounded at side, but hardly wider at any point than at base; disc deeply impressed with moderate-sized punctures which are mostly about as large as spaces between them. *Scutellum* narrowed and obtuse posteriorly, distinctly punctured basally. *Elytron* more than twice as long as prothorax, subevenly rounded in external outline, widest a little anterior to middle; disc deeply and distinctly punctured, the punctures only vaguely arranged in rows on basal half, where most of them are about as large as interspaces, and much sparser, finer, and less regular on posterior half. *Ventral surfaces* with only a few punctures on metasternum, and some vague wrinkling or minute punctures on abdominal sternites. Length 1.85 mm.; breadth 1.05 mm.

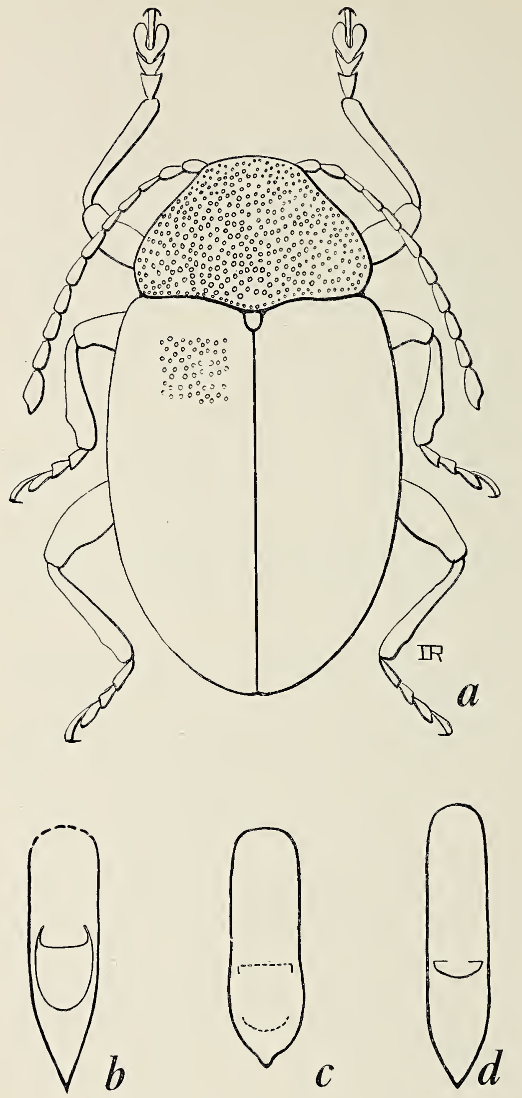

FIG. 20. *a*, *Stygnobia elliptica* Gressitt, n. sp., type; *b*, *Stygnobia elliptica*, aedeagus; *c*, *Stygnobia nandarivatu* Gressitt, n. sp., aedeagus; *d*, *Stygnobia ovalaua* Gressitt, n. sp., aedeagus.

PARATYPES: Length 1.65–2 mm.; breadth 0.95–1.1 mm.

VITI LEVU: Holotype (BISHOP 2427), Nandarivatu, Jan. 1955, Krauss. Six paratopotypes (BISHOP, BM, US), Oct. 18, 1937, Valentine; Sept. 14, 1938, 800 m., Zimmerman; Jan. 1955, Krauss.

Differs from *S. leveri* (Bryant) in having the elytron evenly convex and declivitous at side, and not vertical and ridged behind humerus, as well as the prothorax more narrowed anteriorly. The dorsum is entirely golden green and the legs are entirely pale.

52. ***Stygnobia leveri*** (Bryant), n. comb.

Trichostola leveri Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 511 (Nandarivatu; Taveuni; type in Brit. Mus.).

Cupreous above, black beneath; pubescent; first six antennal segments and legs flavous. Head strongly punctured and pubescent; antenna slender, with last five segments slightly thickened; prothorax strongly punctured and clothed with fine pubescence, strongly transverse, rounded at side; scutellum subquadrate; elytron strongly punctured, the punctures irregular, clothed with gray pubescence; meso- and metasternum strongly punctured; abdominal sternites almost impunctate. Length 2 mm.

VITI LEVU: Nandarivatu (type locality). Ridge west of Nandarivatu, Sept. 11, Mt. Korombamba, Aug. 1, Tholo-i-suva, Aug. 21, Belt road, 60 km. west of Suva, July 23, 1938, Zimmerman. Lami Quarry, near Suva, Mar., May 1951, Krauss. Near Suva, Feb. 6, 1952, Gressitt.

OVALAU: Andubangda, July 15, 1938, Zimmerman.

VANUA LEVU: Daku road, 12 km. east of Lambasa, on *Alphitonia* and *Glochidion*, Oct. 6, Navukuru to Nakawanga, Oct. 7, Nakawanga, on *Couthovia*, *Pipturus*, and *Alphitonia*, Oct. 8, 1955, Gressitt.

TAVEUNI: Near Buthalevu; Waiyevo.

HOSTS: *Alphitonia zizyphoides* (Spreng.) A. Gray; *Glochidion cordatum* (Muell. Arg.) Seem.; *Couthovia corynocarpa* A. Gray; *Pipturus argenteus* var. *lanosus* Skottsb.

53. ***Stygnobia ovalaua*** Gressitt, n. sp.
Fig. 20*d*

Metallic greenish black, slightly bronzy on pronotum, somewhat purplish on elytron, particularly at side; antenna testaceous except for last segment which is pitchy; legs purplish pitchy, testaceous on tarsi and apices of tibiae. Body moderately clothed with curved, posteriorly directed silvery hairs.

Head five-sevenths as broad as prothorax, fairly smooth and even, moderately punctured, more densely so on postocciput. *Antenna* nearly three-fourths as long as body, thickened basally and distally, very slender in third to sixth segments; scape a little longer than second; third slightly shorter than second and fourth; last longest. *Prothorax* about three-fourths as long as broad, somewhat evenly rounded at side, slightly narrower at apex than at base, slightly narrower than elytra; disc heavily punctured, the punctures mostly as wide as interspaces. *Scutellum* suboblong, obtuse behind. *Elytron* broadest near middle, distinctly narrowed posteriorly, vertical at side, somewhat ridged behind humerus; disc unevenly punctured, the punctures rather small, close and irregular on sutural half of basal portion, much stronger, and subseriate on humeral half of base, and much sparser and mostly irregular on posterior half. *Ventral surfaces* deeply punctured in rows on metasternum, feebly rugulose on abdomen. Length 2.08 mm.; breadth 1.17 mm.

OVALAU: Holotype, female (BISHOP 2428), Andubangda, 600 m., July 15, 1938, Zimmerman. Five paratopotypes (BISHOP, BM), same data.

MOALA: One, Naroi, 200 m., Aug. 24, 1938, Zimmerman.

VITI LEVU: One specimen, Tholo-i-suva, July 27, 1938, Zimmerman; another, possibly

this species, Nandarivatu, Sept. 6, 1938, Zimmerman.

Differs from *S. leveri* (Bryant) in having the prothorax narrower than the elytra, and more deeply and less closely punctured, the elytron a little more heavily punctured, and the dorsum more bronzy and more feebly pubescent.

EPINODOSTOMA Gressitt, new genus

Head deep, strongly raised on occiput, with a deep groove bordering upper half of eye; antenna distinctly thickened in distal half; prothorax feebly margined at side, slightly narrower than elytra, nearly as long as broad; elytra parallel, rounded apically, regularly seriate-punctate with one or two extra scutellar rows; middle and hind tibiae emarginate preapically on outer sides; tarsal claws bifid or toothed. Type: *Epinodostoma alocasiae* Gressitt, n. sp.

This genus differs from *Nodostoma* in being more slender, in having a deep groove above the eye, and in having the prothorax hardly margined laterally. Heretofore, the tarsal claw character—bifid (branched) or appendiculate (toothed basally)—has been considered of tribal value in this subfamily. However, though the following two species seem to differ on this point, they are otherwise extremely closely related. This fact, and other problems encountered in this study, indicate that this character has received undue importance, or that other generic characters have been overlooked.

54. *Epinodostoma alocasiae* Gressitt, n. sp.
Fig. 21

Shiny black with a purplish bronzy tinge, particularly on elytron; basal half of antenna, and much of tibiae and tarsi reddish. Glabrous on elytron, with very fine subrecumbent hairs on pronotum, and with sparse suberect hairs on ventral surfaces.

Head three-fourths as broad as prothorax, deeper than wide, with moderately strong punctures, and a deep groove bordering upper half of eye; occiput strongly raised above. *Antenna* three-fifths as long as body, moderately stout except for third to sixth segments which are slender; scape a little longer than second; third subequal to scape, fifth, and sixth; fourth slightly longer; seventh to last each a little longer than fourth. *Prothorax* nearly seven-eighths as broad as long, more than seven-eighths as broad as elytra, rounded at side, slightly narrower at apex than at base, broadest one-third from base, strongly convex; anterior portion strongly raised, and also strongly convex in dorsal outline of anterior margin; lateral margin barely perceptible; disc deeply and subregularly punctured, with roughly 15 punctures along an approximate median line. *Scutellum* slightly longer than broad, narrowed and subrounded apically. *Elytron* two and one-fourth times as long as prothorax, subparallel-sided in slightly more

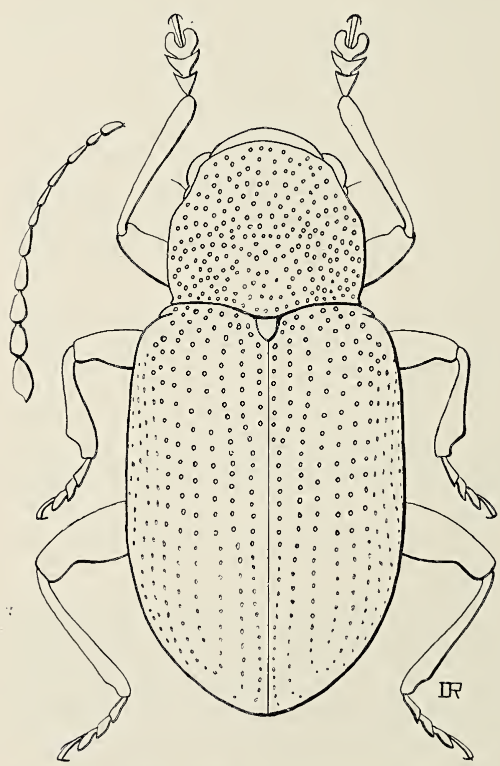

FIG. 21. *Epinodostoma alocasiae* Gressitt, n. sp.

than basal half, moderately narrowed posteriorly, strongly and subevenly convex, nearly vertical at side; disc regularly punctured in 11 rows at middle, with an extra scutellar row and an extra subhumeral row basally; punctures deep, distinct to apex, mostly separated longitudinally by spaces subequal to their diameters. *Metasternum* moderately punctured; abdominal sternites finely and irregularly punctured. Tarsal claws apparently bifid. Length 2.2 mm.; breadth 1.07 mm.

PARATYPES: Length 2.05–2.1 mm.; breadth 1–1.1 mm.

VANUA LEVU: Holotype, female (BISHOP 2422), Nakawanga, 50 m., central Vanua Levu, on *Alocasia*, Oct. 9, 1955, Gressitt; two female paratopotypes, same data.

HOST: *Alocasia macrorrhiza* (L.) Schott.

Differs from the following species in being smaller, more metallic, with the prothorax broader and more finely punctured, and the elytron more purplish and more finely punctured, and with one instead of two extra scutellar puncture-rows.

55. ***Epinodostoma elongata*** Bryant, n. sp.
Fig. 22*a*, *b*

Elongate, black, with metallic sheen, prothorax closely punctured, rounded at side. Elytron more strongly punctate-striate. Antenna and legs deep fulvous to pitchy.

Head metallic black, finely and closely punctured, with a median depression. *Antenna* extending almost to middle of elytron, deep fulvous; five apical segments slightly thickened. *Prothorax* about as broad as long, the sides feebly rounded; metallic, black, closely punctured. *Scutellum* small, triangular, impunctate. *Elytron* elongate, parallel-sided and rounded at apex, metallic, black, strongly punctate-striate. *Legs* deep fulvous; femora darker than tibiae; tarsal claws appendiculate. Length 2–2.5 mm.

VITI LEVU: Holotype (BISHOP 2423), Mt. Victoria, Tholo North, Sept. 13, 1938, beating shrubbery, Zimmerman; nine specimens.

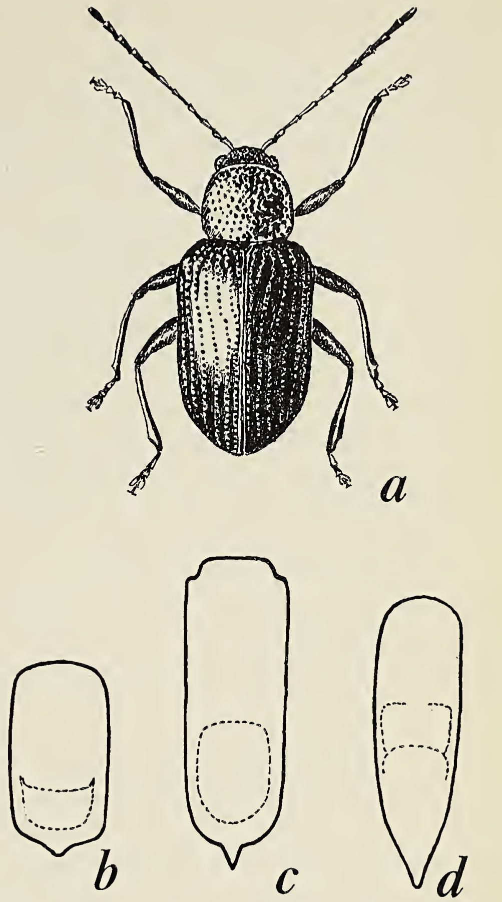

FIG. 22. *a*, *Epinodostoma elongata* Bryant, n. sp., type; *b*, *Epinodostoma elongata*, aedeagus; *c*, *Stethotes rufipes*, aedeagus; *d*, *Stethotes setosa* Gressitt, n. sp., aedeagus.

Somewhat similar to *V. pallipes* Bryant on account of its narrow elongate form, but the color of the legs very distinctive.

(TYPOPHORINI)

Genus EURYDEMUS Chapuis

Eurydemus Chapuis, 1874, Gen. Col. 10: 333 (type *E. insignis* Chapuis; Australia). Lefevre, 1885, Soc. Sci. Liege, Mem. Ser. 2, 11: 136.

Body large; head broad; antenna long and slender; prothorax narrowed anteriorly, dis-

tinctly margined; scutellum rounded; elytron striate-punctate; humerus prominent; femora swollen and toothed beneath; tarsi broad.

The following two species have been united, but appear quite distinct on the basis of material before us.

KEY TO FIJIAN SPECIES OF *Eurydemus*

1. Elytral punctures in regular, widely spaced longitudinal rows; dark reddish castaneous . . . . **grandis**

   Elytral punctures larger, in numerous partly irregular rows, without broad smooth interpunctural strips; paler, somewhat brick-red . . . . **insignis**

56. Eurydemus grandis (Baly)

Rhyparida grandis Baly, 1861, Jour. Ent. 1: 287 (New Caledonia).
Eurydemus grandis Baly, 1878, Linn. Soc. London, Jour. 14: 259.

Bright reddish, dark on distal portion of antenna, on tarsi, and parts of tibiae and on femoral apices. *Head* finely and closely punctured; *antenna* slender, segments subequal in length except second and third segments shorter, with second two-thirds as long as third; *prothorax* finely and fairly closely punctured; *elytron* regularly punctured in slightly sinuous, but even, rows, the interspaces between rows mostly twice as wide as punctures. Length 9–10.8 mm.; breadth 5–5.8 mm.

OVALAU: Wainiloka, Sept. 29, 1937, Valentine.

VANUA LEVU: Nakawanga, on *Phaleria* and *Flacourtia*, Oct. 9, 1955, Gressitt.

KANDAVU: Wai Salima and Ndavingeile, Apr. 1941, Krauss.

HOSTS: *Terminalia* leaf (Lever); *Phaleria acuminata* (A. Gray) Gilg (?), and *Flacourtia vitiensis* (Seem.) A. C. Smith.

57. Eurydemus insignis Chapuis

Eurydemus insignis Chapuis, 1874, Gen. Col. 10: 334, note 1, pl. 122, fig. 4 (Australia); Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 482 (Fiji).

Bright reddish brown, tinged in part with pitchy; somewhat brick-red on elytron. *Head* finely and somewhat closely punctured; *antenna* slender, segments subequal in length except second shorter; *prothorax* finely, but not very closely, punctured; *elytron* somewhat heavily punctured, but the punctures partly irregular, only in part forming regular rows. Length 11 mm.; breadth 5.5 mm.

TAVEUNI: Ngathabula (Qacabula) on *Tabernaemontana*, Nov. 1937, Valentine.

HOST: *Tabernaemontana* sp.

Genus STETHOTES Baly

Stethotes Baly, 1867, Ent. Soc. London, Trans. Ser. 3, 4: 254 (type here designated as *Pyropida elegantula* Baly, 1864; Amboina).

Ovate, strongly convex; eye entire, strongly swollen; prothorax narrower than elytra, distinctly narrowed anteriorly, feebly margined at side; elytron strongly narrowed posteriorly; femora swollen, generally toothed beneath (not so in Fijian species). The following may require a new genus.

KEY TO FIJIAN SPECIES OF *Stethotes*

1. Pronotum striate-punctate near anterior border; pronotum with more than 15 punctures in an approximate longitudinal median row; elytron with a few regular rows of punctures . . . . **rufipes**

   Pronotum not striate-punctate, with less than 12 punctures in an approximate longitudinal median row; and with a submedian impunctate area; elytron with suberect hairs throughout; elytron with many subregular rows of punctures . . . . **setosa**

58. Stethotes rufipes Bryant
Fig. 22*c*

Stethotes rufipes Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 426, fig. 9 (Mt. Lautoka, Loloti; type in Brit. Mus.).

Pitchy black, sometimes tinged with bluish; pronotum sometimes reddish; antenna testaceous; legs reddish. *Head* sparsely punctured, slightly striate on postocciput; *antenna* slender, third segment slightly longer than second, following subequal or slightly longer; *prothorax* rather strongly and evenly punctured, slightly striate near anterior border; *elytron* with punctures in regular rows, mostly much smaller than interspaces, one or two rows of outwardly directed pale hairs along suture in posterior two-thirds, and a small tuft of silvery hairs near apex. Length 3–3.5 mm.

VITI LEVU: Mt. Lautoka, Loloti; Nandarivatu, 1050 m., Sept. 5, and Belt road west of Suva near Korolevu, July 26, 1938, Zimmerman; Vuti Ndawa, Aug. 27, 1925, W. H. Ford.

It is interesting to note that this species is extremely similar in dorsal appearance to a certain cryptorhynchine weevil occurring in Fiji.

59. *Stethotes setosa* Gressitt, n. sp.

Fig. 22*d*

Dark reddish brown, slightly pitchy above, and on antenna beyond third segment; paler reddish brown on abdomen and first three antennal segments; legs reddish pitchy. Body moderately clothed above with fine suberect hairs, mostly dark on pronotum, as well as transversely oblique silvery hairs along suture, particularly in posterior half; ventral surfaces irregularly clothed with fine suberect hairs.

Head slightly narrower than prothorax, about as wide as deep, sparsely but distinctly punctured; frontoclypeus largely impunctate. *Antenna* slender, two-thirds as long as body; scape fully twice as long as second segment; third barely longer than second, shorter than fourth; fourth slightly longer than fifth; sixth shorter than fifth; seventh and following much longer. *Prothorax* nearly as long as broad, barely four-fifths as broad as elytra, narrowed apically; disc strongly and somewhat closely punctured, with an impunctate area anterior to center. *Scutellum* longer than broad, subrounded apically. *Elytron* more than twice as long as prothorax, strongly narrowed posteriorly, widest at end of basal third; disc with about 15 irregular rows of fine punctures, with one or two extra scutellar rows. *Metasternum* strongly punctured; abdomen finely punctured. Length 2.9 mm.; breadth 1.35 mm.

PARATYPES: Length 2.55 mm.; breadth 1.35 mm.

VITI LEVU: Holotype, male (BISHOP 2424), Belt road, 25 km. west of Suva, July 29, 1938, beating shrubs, Zimmerman; three paratypes, males, Lami Quarry, near Suva, May 1951, Krauss.

Differs from *S. rufipes* Bryant in being more reddish, more shiny, less elongate, with the pronotum more strongly punctured and not striate-punctate, the elytron somewhat bluish, more finely and closely punctured, and with the dorsum clothed with fine hairs throughout.

Tribe ADOXINI

Genus PARADEMOTINA Gressitt, new genus

Head nearly as broad as prothorax; eye prominent; occiput convex, finely carinate medially; antenna slender; prothorax slightly broader than long, very feebly margined at side, closely punctured, just over two-thirds as broad as elytra; elytron suboblong, subregularly lineate-punctate; middle and hind tibiae emarginate preapically on outer side; tarsal claws bifid, but with the accessory process near base, suggesting the appendiculate condition. Dorsal surface clothed with minute scales on elytron and scale-like hairs on pronotum. Type: *Parademotina aureotincta* Gressitt, n. sp.

The prothorax appears from some angles to be margined at side, and from other angles appears unmargined. There is a feeble irregular ridge along the side, but not a true margin.

The type of this genus differs from species of *Demotina* Baly in being narrower and shal-

lower, in having the head shorter and broader, the prothorax subrectangular, and the aedeagus much more slender and attenuated apically.

60. ***Parademotina aureotincta*** Gressitt, n. sp.
Fig. 23*a*, *b*

Black to pitchy black, paler on elytral base, clothed above with irregular minute golden scales or scale-hairs, fairly dense on side of occiput, in certain lights forming a sinuous longitudinal stripe on side of pronotal disc, and on elytron forming about ten more or less distinct sublongitudinal small spots, roughly arranged in about three obliquely transverse bands, but also with scattered scales between the spots, and particularly on extreme base and suture near scutellum; front portion of head testaceous; antenna testaceous, becoming brown distally; ventral surfaces reddish brown, with abdomen testaceous; legs testaceous, but pitchy on distal portions of femora and bases and apices of tibiae; abdomen with some very long erect hairs.

Head as broad as prothorax, wider than deep, granulose and finely carinate medially on occiput; interantennal space about one-half as wide as interocular space. *Antenna* three-fourths as long as body; scape stouter than second segment, and one-half again as long; third to sixth slender; third and fourth subequal; fourth barely longer than fifth; sixth distinctly longer than fifth; seventh to tenth longer, subequal, last longest. *Prothorax* nine-tenths as long as broad, three-fourths as broad as elytra, moderately rounded at side; disc somewhat uneven, closely and somewhat deeply punctured, with roughly 20 punctures in an approximate median line. *Scutellum* subtrapeziform, obtuse apically. *Elytron* twice as long as prothorax, gradually narrowed and rounded apically; disc distinctly and uniformly punctured in regular rows, with two or three irregular extra rows at base near suture; most of punctures slightly smaller than interspaces. *Ventral surfaces* moderately punctured on metasternum, feebly wrinkled and partly punctulate on abdominal sternites. Length 2.05 mm.; breadth 1.08 mm.

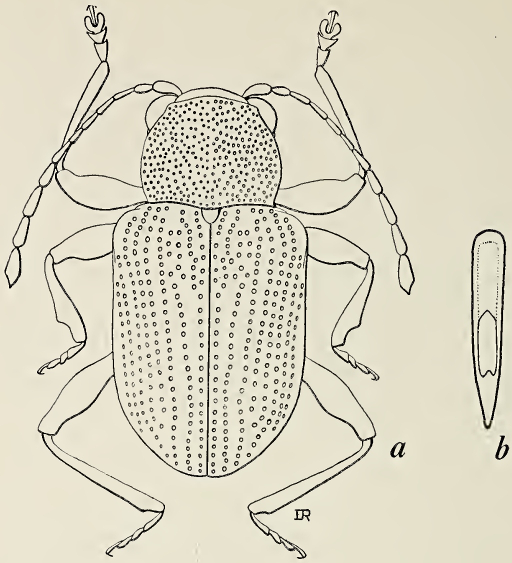

FIG. 23. *a*, *Parademotina aureotincta* Gressitt, n. sp., type; *b*, *Parademotina aureotincta*, aedeagus.

PARATYPES: Length 2.15–2.4 mm.; breadth 1.1–1.25 mm. Some with golden spots very vague.

VITI LEVU: Holotype (BISHOP 2429), near Suva, 100 m., Feb. 6, 1952, Gressitt. Four paratypes: Nandarivatu, 900–1100 m., Sept. 3–6, 1938, Zimmerman; Lautoka Mts., Oct. 23, 1921, Greenwood.

Differs from *Demotina obscurata* Bryant in being smaller, more dorso-ventrally compressed, darker, with small golden spots, with the head broader and shallower, the prothorax more rectangular, and the elytron less heavily punctured.

Genus DEMOTINA Baly

Demotina Baly, 1863, Jour. Ent. 2: 158 (type: *D. bowringii* Baly; China); 1867, Ent. Soc. London, Trans. (3) 4(2): 84; Chapuis, 1874, Gen. Col. 10: 281; Lefevre, 1885, Soc. Sci. Liege, Mem. Ser. 2, 11: 80; Jacoby, 1908, Fauna of India 2: 427.

Head narrower than prothorax; eye coarsely faceted; occiput generally finely carinate; antenna thickened distally; prothorax generally narrowed apically, often feebly margined at side; elytron suboblong; middle and hind tibiae emarginate preapically on outer side; tarsal claws bifid; dorsum clothed with fine scales or hairs.

KEY TO FIJIAN SPECIES OF *Demotina*

1. Elytron with some isolated fine erect hairs, or many short erect hairs, distinctly rugose and nodose if erect hairs not distinct 2
   Elytron without erect hairs, not strongly rugose 6

2(1). Pronotum often uneven or nodose; elytral erect hairs scattered, varying in length 3
   Pronotum and elytron evenly convex; pronotum densely pubescent; elytron with numerous short suberect hairs of similar length . . . . **pubescens**

3(2). Pronotum with rather distinct nodes or tubercles 4
   Pronotum only moderately uneven, or body distinctly less than one-half as broad as long 5

4(3). Elytron with premedian and preapical swellings and other irregularities; pronotum deeply punctured, with central tubercles about as widely spaced as one-half breadth of pronotum; largely blackish . . . . **rugosa**
   Elytron without premedian and preapical swellings; pronotum finely punctured, with central tubercles conical, less widely separated than one-half breadth of pronotum; rarely blackish . . . . **nodosa**

5(3). Body less than one-half as broad as long; hind femur exceeding elytral apex . . . . **fragilis**
   Body fully one-half as broad as long; hind femur not exceeding elytral apex . . . . **veitchi**

6(1). Pronotum broadest near base, distinctly flattened above, not evenly convex, finely punctured 7
   Pronotum rounded at side, as a rule strongly convex, or cylindrical-oblong, not distinctly flattened above and broadest near base, coarsely or finely punctured 9

7(6). Pronotum dull, with a vague subtransverse raised area anterior to center 8
   Pronotum shiny, subglabrous, rather smooth, without a transverse premedian raised area; elytron testaceous with dark brown sutural stripe and three suboblique bands extending out from stripe, the posterior two reaching side . . . . . . **irregularis**

8(7). Elytron uniformly pale brown or with irregular transverse darker bands . . . . **dissimilis**
   Elytron with a median dark brown stripe . . . . **striata**

9(6). Elytron marked with some more or less distinct spots of white, silvery, or goldish hairs or scales 10
   Elytron not marked with pale spots of pubescence or scales 12

10(9). Elytron with several pale spots arranged somewhat in bands 11
   Elytron subglabrous, with four or five conspicuous spots of silvery pubescence, arranged somewhat irregularly, but partly in a sublongitudinal line . . . . **albonotata**

11(10). Prothorax broader than long, not very strongly punctured; dorsum largely brown, often with silvery white longitudinal spots arranged in two suboblique bands behind middle of elytron . . . . **obscurata**

Prothorax as long as broad, very strongly punctured; elytron with two or three obliquely transverse bands formed of small spots of white pubescence which are sometimes indistinct because of general pale pubescence . . . . **bifasciata**

12(9). Dorsum generally black, appearing more or less glabrous, at least on pronotum 13

Dorsum rarely black, as a rule distinctly pubescent 14

13(12). Dorsum black with a golden tinge; pronotum nearly glabrous, shiny, rarely reddish . . . . **metallica**

Dorsum black, non-metallic, thinly, but distinctly, pubescent . . **pallipes**

14(12). Dorsum largely pale, or pale marked with blackish, often without very dense golden pubescence 15

Dorsum pitchy black to dark reddish brown, with conspicuous golden to golden-buff pubescence; length 2–2.7 mm. . . . . **evansi**

15(14). Prothorax distinctly broader than long, distinctly convex at side . . . 16

Prothorax about as long as broad, feebly convex at side, much narrower than elytra . . . . **cylindricollis**

16(15). Elytron with equivalent of about two extra rows of punctures near scutellum 17

Elytron with only one extra row of punctures near scutellum; dorsum entirely pale . . . . **fulva**

17(16). Dorsum marked with spots of pitchy; length generally over 2.5 mm.; elytron in large partly thinly golden-buff pubescent . . . . **vitiensis**

Dorsum not distinctly marked with pitchy; length generally under 2.0 mm.; elytron in part rather densely golden pubescent . . . . . **glochidiona**

61. *Demotina pallipes* Bryant, n. sp.
Fig. 24*a*

Deep brown to black, with antenna and tarsi pale; feebly clothed with adpressed scales; prothorax closely punctured; elytron punctate-striate, the punctures large and round.

Head dark brown, finely punctured, clothed with slight pubescence. *Antenna* extending just beyond base of elytron, fulvous with apical segments slightly darker. *Prothorax* slightly broader than long, dark brown, closely punctured, clothed with slight pubescence; side rounded and slightly contracted in front; widest just before base. *Scutellum* dark brown, triangular. *Elytron* dark brown; punctate-striate, punctures large and round; clothed with adpressed scales. *Legs* dark brown; tarsi pale fulvous. Length 2–2.5 mm.

LAU: Holotype (BISHOP 2430), Mvana, Vanua Mbalavu I., Aug. 9, 1938, Zimmerman; beating shrubs. Mbavatu, Vanua Mbalavu, Aug. 16, 1938, Zimmerman; Sept. 23, 1924, Bryan. Naiau, Sept. 12, Tuvutha, Sept. 11, Avea, Sept. 22, Thikombia, Sept. 26, Yathata, Oct. 1, 1924, Bryan; Munia I., Aug. 3, 1938, Zimmerman and Kondo. One hundred fifteen specimens.

FIG. 24. *a*, *Demotina pallipes* Bryant, n. sp., type; *b*, *Demotina glochidiona* Gressitt, n. sp., aedeagus; *c*, *Demotina fulva*, aedeagus.

62. *Demotina glochidiona* Gressitt, n. sp.
Fig. 24*b*

Reddish brown, slightly darker on side of prothorax; legs testaceous, slightly darker on

apices of femora; antenna ochraceous; dorsum clothed with rather dense golden buff pubescence.

Head distinctly narrower than prothorax, deeper than wide, strongly arched and finely rugose-punctate on occiput, a narrow transverse groove between eyes. *Antenna* two-thirds as long as body; scape thicker and longer than second; third to sixth slender, third longer than fourth; fifth and sixth shorter, subequal; seventh and following longer and stouter. *Prothorax* four-fifths as long as broad, three-fourths as broad as elytra, evenly rounded at side, barely narrower at apex than at base; disc evenly convex, very closely and deeply punctured, with roughly 20 punctures in an approximate median line. *Scutellum* narrow, suboblong. *Elytron* twice as long as prothorax, suboblong, narrowed and rounded posteriorly; disc deeply punctured in somewhat sinuous rows, with two extra basal rows near suture, and some extra, and irregular rows at side, punctures on basal portion mostly larger than interspaces, particularly in longitudinal sense. *Ventral surfaces* largely impunctate, with a few fine punctures on abdominal sternites. Length 1.9 mm.; breadth 1.07 mm.

PARATYPES: Length 1.9–2.25 mm.; breadth 1–1.1 mm.

VANUA LEVU: Holotype (BISHOP 2431), Navakuru, 70 m., Oct. 7, 1955, Gressitt. Fourteen paratypes, Daku road, near Gelemumu, 12 km. east of Lambasa, on *Glochidion*, Oct. 6; Navakuru to Nakawanga, on *Glochidion*, Oct. 7; and Nakawanga, 75 m., on *Grewia*, Oct. 8, 1955, Gressitt.

HOSTS: *Glochidion cordatum* (Muell. Arg.) Seem.; *Grewia crenata* (Forst.) Schinz and Guill.

Differs from *D. vitiensis* Bryant in being smaller, almost entirely pale instead of with dark markings, and with denser pubescence of longer hairs or scales.

63. **Demotina fulva** Bryant

Fig. 24*c*

Demotina fulva Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 361, fig. 6 (Labasa; type in Brit. Mus.).

Oblong, subcylindrical; fulvous, clothed with golden adpressed scales, the scales more hair-like and longer on pronotum than on elytron. *Head* carinate medially; *antenna* with scape twice as long as second segment; next four slender and elongate; last five stouter; *prothorax* strongly punctured, rounded at side, contracted in front, widest behind middle; *scutellum* subtriangular; *elytron* oblong, prominent at humerus, strongly punctate-striate; *ventral segments* with scattered punctures, first abdominal sternite more strongly punctured and twice as long as second. Length 2 mm.

VITI LEVU: Vunindawa, May 1941, Krauss; Navai Mill, near Nandarivatu, Sept. 1938, Zimmerman.

VANUA LEVU: Lambàsa (type locality); Mbua, Apr. 1939, Lever; Daku road, near Gelemumu, east of Lambasa, on *Maesa* and *Glochidion*, Oct. 1955, Gressitt.

LAU: Six, questionably this species: Munia I., Aug. 1938, Zimmerman; Mvana, Vanua Mbalavu I., Aug. 1938, Zimmerman; south of Marona, Mango I., Aug. 1938, Zimmerman; Olorua I., Aug. 1924, Bryan; Dakuiloa, Oneata I., Aug. 1938, Zimmerman.

HOSTS: *Maesa persicaefolia* A. Gray (?); *Glochidion cordatum* (Muell. Arg.) Seem.

64. ***Demotina metallica*** Bryant, new name

Fig. 25*a*

Trichostola vitiensis Bryant, 1942, Ann. and Mag. Nat. Hist. Ser. 11, 9: 509 (Nandarivatu, Nausori; type in Brit. Mus.).

Deep bronze above, black beneath; elytron clothed with gray pubescence; labrum, legs, and first three antennal segments fulvous.

Head closely punctured with fine pubescence; *antenna* slender, third to sixth segments slender and subequal, last acuminate; *prothorax* slightly transverse, strongly punctured, with fine scattered pubescence, and rounded side; *scutellum* subquadrate, impunctate; *elytron* parallel-sided, rounded apically, strongly punctate-striate, with very fine pubescence; *meso-* and *metasternum* strongly punctured. Length 2 mm.

VITI LEVU: Nandarivatu; Nausori. Nandarivatu, Oct. 1937, Valentine and ridge west of Nandarivatu, 800 m., Mt. Victoria, 900 m., Sept. 1938, Zimmerman; Lami Quarry, May 1951, Mar. 1955, Krauss.

OVALAU: Thawathi, Draiba trail, July 1938, Zimmerman.

VANUA LEVU: Nakawanga to Wailevu, Oct. 1955, Gressitt.

One hundred twenty-five specimens.

65. **Demotina vitiensis** Bryant

Demotina vitiensis Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 359, fig. 5 (E. Viti Levu; type in Brit. Mus.).

Plum-brown, with darker markings forming patches and irregular transverse bands; antenna with four basal segments flavous, the rest fuscous; prothorax clothed with fine whitish adpressed scales; elytron with very short fine scales. *Head* with short adpressed whitish scales; *antenna* slender, scape longer and more swollen than second; third and fourth long and slender, sixth a little shorter than fifth, and last five more swollen and subequal; *prothorax* slightly transverse, rounded at side, strongly punctured, median portion of base and side darker; *scutellum* subquadrate; *elytron* oblong, rounded apically, with scales shorter than those on pronotum, strongly punctate-striate, with four incomplete dark bands. Length 2.5 mm.

VITI LEVU: Nanduruloulou; Nausori; Suva; Mt. Lautoka. Nandarivatu and ridge west of Nandarivatu, 1000 m., Sept., Mt. Korombamba, Aug. 1938, Zimmerman; Belt road

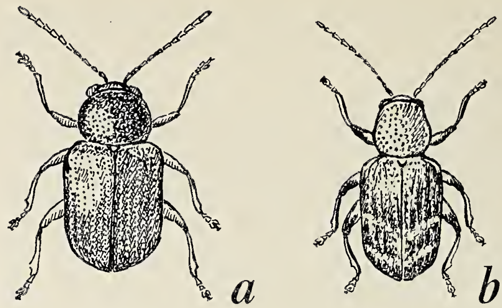

FIG. 25. *a*, *Demotina metallica* Bryant, n. n.; *b*, *Demotina bifasciata* Bryant, n. sp.

14 km. west of Suva, Tholo-i-suva, July 1938, Zimmerman; Vunindava, May 1941, Krauss; Lami, May 1951, Krauss; Nasinu, Apr. 1951, Krauss.

OVALAU: A doubtful specimen, Andubangda, July 1938, Zimmerman.

VANUA LEVU: Daku road, east of Lambasa, on *Glochidion* (100 specimens), *Macaranga*, *Decaspermum*, and *Psidium*, Oct. 1955, Gressitt; Nakawanga, Oct. 1955, Gressitt.

LAU: Olorua I., Fulanga I., Aug. 1924, Bryan; Munia I., Aug. 1938, Zimmerman. Some doubtful specimens, Mvana, Vanua Mbalavu I., Aug. 1938, Zimmerman; Aiwa I. and Oneata I., Aug. 1924, Bryan.

One hundred eighty-four specimens.

HOSTS: *Glochidion cordatum* (Muell. Arg.) Seem.; *Macaranga membranacea* Muell. Arg.; *Decaspermum fruticosum* Forst.; *Psidium guajava* L.

66. ***Demotina bifasciata*** Bryant, n. sp.
Fig. 25*b*

Oblong, subcylindrical, gray-black covered with short golden scale-like hairs; strongly punctured, elytron with two transverse bands formed of white patches of pubescence behind middle.

Head more or less fulvous, impunctate, clothed with short golden pubescence. *Antenna* fulvous, extending to middle of elytron; five terminal segments slightly thickened. *Pro-*

thorax about as broad as long, gray-black; anterior margin slightly fulvous, strongly punctured, covered with short golden scale-like hairs, with side feebly rounded. *Scutellum* gray-black, impunctate. *Elytron* gray-black, basal portion narrowly fulvous, subcylindrical, rounded at apex, strongly punctate-striate, clothed with fine golden scales, with two transverse bands behind middle, formed of whitish scale-like patches. *Underside* fulvous, with ventral segments of abdomen two to four about equal to each other and impunctate. *Legs* fulvous. Length 2 mm.

VITI LEVU: Holotype (BISHOP 2432), Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman; 14 specimens. Mt. Victoria, 950 m., Tholo North, Sept. 13, 1938, Zimmerman, 17 specimens. Lami Quarry, May 1951, Krauss, two specimens.

Allied to *D. obscurata* Bry., but smaller, not so dark, and with the transverse white patches on the elytron more numerous and differently placed.

67. **Demotina albonotata** Bryant

Demotina albonotata Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 364 (Loloti; type in Brit. Mus.).

Black, nitid, clothed with very fine scales; antenna ferrugineous, flavous on first four segments; elytron with three tufts of silky white scales, on base, side, and apex, respectively. *Head* carinate medially, a white patch of scales near inner margin of eye; *antenna* slender in middle; *prothorax* coarsely rugose-punctate, with fine grayish scales; *elytron* elongate, tapering. Length 2.75 mm.

VITI LEVU: Loloti. Belt road 80 km. west of Suva, July 26, 1938, Zimmerman; Navai-Nasonga trail, Sept. 12, 1938, Zimmerman; Lami Quarry, near Suva, May 1951, Krauss.

OVALAU: Andubangda, July 18, 1938, Zimmerman.

MOALA: Naroi, Aug. 24, 1938, Zimmerman. Thirteen specimens.

68. **Demotina evansi** Bryant

Demotina evansi Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 362, fig. 7 (Quilai; type in Brit. Mus.).

Subcylindrical; gray-black, opaque, with a ferrugineous pattern on elytron, and clothed with adpressed short whitish scales which form longitudinal lines between elytral striae; appendages largely ferrugineous; ventral surfaces fuscous; legs reddish, in part fuscous or ferrugineous. *Head* rugose; *antenna* with scape longer than second segment, both more swollen than the four following; *prothorax* rugosely punctured, broadest behind middle; *elytron* oblong, strongly punctate-striate. Length 2 mm.

VANUA LEVU: Twenty, Daku road, east of Lambasa, Oct. 6, 1955, on *Glochidion*, *Commersonia*, *Macaranga*, and *Maesa*, Oct. 6, 1955, Gressitt; one, Nakawanga, Oct. 8, 1955, Gressitt.

TAVEUNI: Quilai (type locality).

HOSTS: *Glochidion cordatum* (Muell. Arg.) Seem.; *Macaranga membranacea* Muell. Arg.; *Commersonia bartramia* (L.) Merr.; *Maesa persicaefolia* A. Gray (?).

69. **Demotina obscurata** Bryant

Demotina obscurata Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 363, fig. 8 (Waiyevo; type in Brit. Mus.).

Gray-black, covered with short fine white scales; tibiae, tarsi, and six basal segments of antenna ferrugineous; elytron clothed with fine white scales and with five white patches of scales, three at middle and two at apex. *Head* with scales thicker and forming a white line near inner margin of eye; *antenna* slender, with scape a little longer than second segment and third one-half again as long as second; third to sixth long, slender and equal; *prothorax* finely punctured, about as broad as long, with scales longer than those of elytron; *elytron* oblong, tapering, strongly punctate-striate. Length 3 mm.

VITI LEVU: Eleven, questionably this species: Nandarivatu, Mt. Victoria, Navai-Nasonga trail, 1000 m., Sept. 1938, Zimmerman.

VANUA LEVU: Two, possibly this species: Daku road, east of Lambasa, on *Alphitonia*, Oct. 6, 1955, Gressitt.

TAVEUNI: Waiyevo (type locality).

HOST: *Alphitonia zizyphoides* (Spreng.) A. Gray.

70. **Demotina dissimilis** Bryant

Demotina dissimilis Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 358, figs. 3, 4 (Waiyevo; type in Brit. Mus.).

MALE: Plum-brown with adpressed whitish scales forming a pattern on elytron; antenna and legs fulvous. *Head* feebly punctured, carinate medially; *antenna* long and slender, fourth segment equal to second and third together; *prothorax* strongly and remotely punctured, widest behind middle; *scutellum* subquadrate; *elytron* oblong, strongly punctate-striate.

FEMALE: Stouter than male; antenna shorter and stouter; elytral pattern more defined, forming two wavy transverse bands on apical portion.

Length 3–3.25 mm.

VITI LEVU: Nandarivatu, Sept. 1938, Zimmerman, Jan. 1955, Krauss; Waito, Naivithula, and Korovou, Tailevu, Sept. 1937, Valentine; Navai Mill, Sept. 1938, Zimmerman; Mt. Korombamba, Aug. 1938, Zimmerman; Suva, Nov. 1899, Koebele; Lami, Mar. 1951, Mar. 1955, Krauss; Mbau, Apr. 1951, Krauss; Tholo-i-suva, Apr. 1951, Krauss; near Suva, Feb. 1952, Gressitt.

OVALAU: Thawathi, Wainiloka, Andubangda, July 1938, Zimmerman.

VANUA LEVU: East and south of Lambasa, Navakuru to Nakawanga, and Nakawanga, Oct. 1955, Gressitt.

TAVEUNI: Waiyevo (type locality). Ngathabula, Nov. 1937, Valentine; 1931, Lever, on *Clidemia*.

MOALA: Naroi, Aug. 1938, Zimmerman; Matuku I., July 1924, Bryan.

LAU: Munia I., Aug. 1938, Zimmerman; Namuka I., Aug. 1924, Bryan; Mango I., Sept. 1924, Bryan; Matuku I., 1924, Bryan.

One hundred twenty-five specimens.

HOSTS: *Clidemia hirta* (after Lever); *Macaranga* sp., *Syzygium*, prob. *seemannianum* Merr. and Perry; *Psidium guajava* L.

71. ***Demotina irregularis*** Bryant, n. sp.
Fig. 26

Oblong subcylindrical; head fuscous; prothorax, antenna, and legs fulvous; elytra with an irregular gray-black pattern down the median portion, sides and suture flavous.

Head broadly fuscous near eye; occiput slightly fulvous; clothed with very short fine hairs. *Antenna* extending just beyond middle of elytron, first two segments slightly dilated; remainder elongate and slender; five apical segments slightly thickened. *Prothorax* fulvous, broadest just behind middle; side contracted in front; clothed with very short fine golden hairs. *Scutellum* fulvous, triangular, impunctate. *Elytra* slightly broader than base of the prothorax; side margin with an irregular

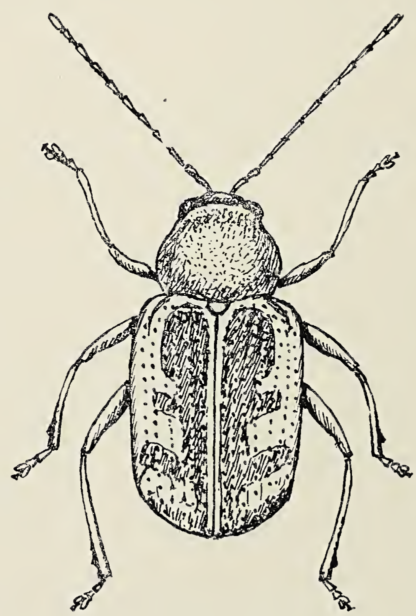

FIG. 26. *Demotina irregularis* Bryant, n. sp., type.

flavous pattern; suture narrowly flavous, the median portion forming a gray-black pattern running into the flavous margin; punctate-striate, clothed with very short pubescence. *Legs* fulvous. *Underside* with the meso- and metasternum fuscous; ventral segments of the abdomen fulvous. Length 2.5 mm.

VITI LEVU: Holotype (BISHOP 2433), Nandarivatu, 1100 m., Sept. 6, 1938, Zimmerman.

A very distinct species on account of the irregular pattern on the elytra.

72. *Demotina striata* Bryant, n. sp.

Fig. 27

Brown; head, prothorax, underside, and legs darker than elytron, clothed with adpressed scales; elytron paler with a longitudinal dark stripe between suture and side margin.

Head dark brown clothed with short silvery pubescence. *Antenna* extending just beyond base of elytron; fulvous, with five apical segments slightly darker. *Prothorax* dark brown clothed with fine adpressed scales, transverse, widest just before base, side rounded and contracted in front. *Scutellum* dark brown, subquadrate, impunctate. *Elytron* pale brown clothed with ashy adpressed scales, with a longitudinal dark stripe between suture and side margin. Length 4 mm.

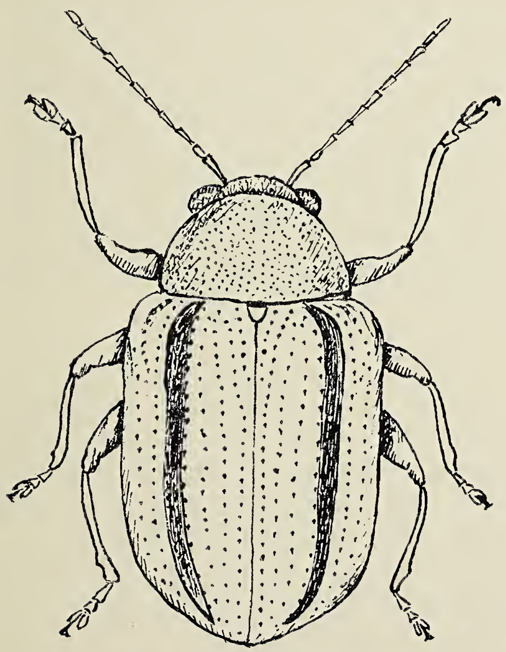

FIG. 27. *Demotina striata* Bryant, n. sp., type.

VITI LEVU: Holotype (BISHOP 2434), Nandarivatu, Sept. 2, 1938, Zimmerman. Six paratopotypes, five, same data as type, one, Jan. 1955, Krauss. Also, four not designated paratypes: Belt road, 14 km. west of Suva, July 1938, Zimmerman; Lami Quarry, July 1938, Zimmerman, and May 1951, Krauss.

OVALAU: Andubangda, July 18, 1938, Zimmerman, one specimen; near Levuka, July 10, 1938, Zimmerman, one specimen.

A very distinct species on account of the well marked longitudinal dark stripe on the elytron.

73. *Demotina pubescens* Gressitt, n. sp.

Fig. 28

FEMALE: Reddish brown, in part darker, largely clothed above with pale golden-buff to silvery buff pubescence, consisting largely of short suberect hairs, as well as minute hair-scales: head reddish, pitchy on each side of occiput; antenna reddish, duller in distal half; prothorax reddish brown, marked with blackish at sides, and a little on center; elytron reddish brown with a weak dark band anterior to middle and a slightly broader one just behind middle, and the scales on these bands dark reddish; ventral surfaces paler reddish, glabrous except for pale pubescence at side of thorax; legs reddish ochraceous, paler on tarsi.

Head four-fifths as broad as prothorax, deeper than wide, strongly punctured and glabrous on frontoclypeus; finely punctured, pubescent, and carinate on occiput. *Antenna* two-thirds as long as body, fairly slender; scape one-half again as long as second segment, about as long as third; fourth to sixth subequal, slender; seventh to tenth equal in length to preceding, slightly stouter; last slightly longer. *Prothorax* seven-eighths as

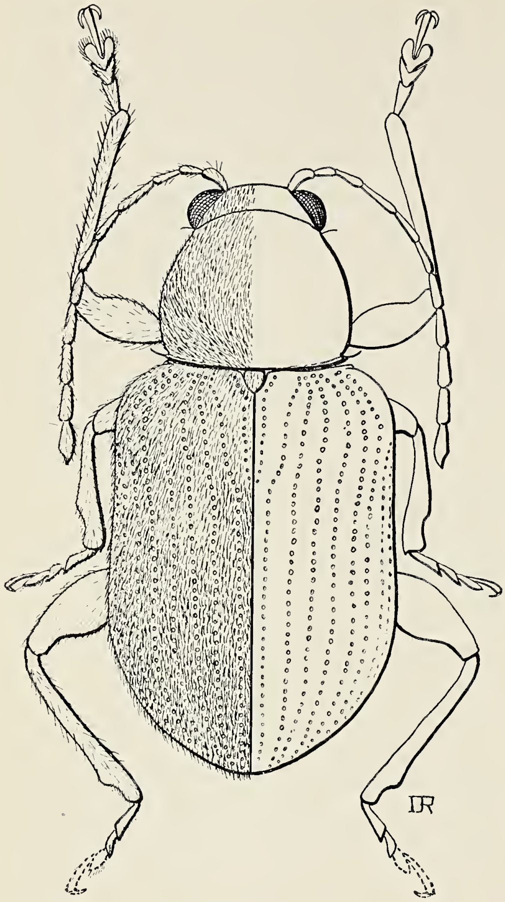

FIG. 28. *Demotina pubescens* Gressitt, n. sp.

long as broad, two-thirds as broad as elytra, rounded at side, widest near base; disc somewhat evenly convex, very finely and closely punctured. *Scutellum* subtrapeziform, obtuse apically. *Elytron* slightly more than twice as long as prothorax, slightly sinuate at side, narrowed apically; disc with about eight regular rows of fairly small punctures on upper surface, and three to five or six on side, which partly branch anteriorly, and a single distinct scutellar row; interspaces fairly broad, and mostly somewhat convex. *Ventral surfaces* largely impunctate, except for parts of side. *Legs* fairly slender; hind femur not reaching apex of abdomen. Length 4.75 mm.; breadth 2.5 mm.

PARATYPES: Length 4.5 mm.; breadth 2.25 mm.

MOALA: Holotype, female (BISHOP 2435), Naroi, 250 m., Moala I., beating shrubs, Aug. 24, 1938, Zimmerman. Paratopotype, female, same data.

Differs from the other Fijian species in having the dorsum clothed with short suberect hairs in addition to minute scales. Differs further from *D. veitchi* Bryant in having the pronotum more even, much more closely and finely punctured, and in having the elytral interstices mostly convex.

74. **Demotina veitchi** Bryant

Demotina veitchi Bryant, 1931, Ann. and Mag. Nat. Hist. Ser. 10, 8: 356, figs. 1, 2 (Labasa, Penang Mts.; type in Brit. Mus.).

MALE: Plum-brown; legs and antenna flavous, clothed with short white scales. *Head* with clypeus rather strongly punctured; *antenna* slender with scape twice as long as second segment, fourth longer than third or fifth, the last seven subequal; *prothorax* finely punctured, with scales longer and more hairlike at side, forming two longitudinal wavy lines enclosing median portion, which is paler; *scutellum* oblong-subpentagonal; *elytron* with darker lines and patches near shoulders, oblong, rounded at apex, strongly punctate-striate, apical half with long white erect hairs, forming longitudinal rows between striae.

FEMALE: Stouter; antenna shorter; elytral scales forming variable pattern.

Length 3–3.5 mm.

VITI LEVU: Penang Mts.; Nandarivatu, 800 m., Sept. 1938, Zimmerman; Tholo-i-suva, and Belt road, 80 km. west of Suva, July 1938, Zimmerman; Bulu, near Sovi, Apr. 1941, Krauss; Lami, Mar. 1951, Krauss; Naivithula, Tailevu, Aug. 1937, Valentine.

OVALAU: Andubangda, Draiba trail, and Wainiloka, July 1938, Zimmerman.

VANUA LEVU: Lambasa.

Fifteen specimens.

75. *Demotina fragilis* Gressitt, n. sp.
Fig. 29

Pale reddish brown, in part paler or darker: head reddish brown; antenna pale ochraceous; prothorax reddish brown, a pitchy stripe along each side of disc, elytron pale reddish brown, with some small irregular darker brown marks; ventral surfaces pale reddish brown, nearly testaceous on abdomen; legs testaceous, pitchy before femoral apices, and near tibial bases and apices. Dorsum somewhat unevenly clothed with minute buffy scale-hairs and with scattered erect hairs, particularly on posterior half of elytron.

Head five-sixths as broad as prothorax, slightly broader than deep, distinctly and not very closely punctured on frontoclypeus; occiput finely and sparsely punctured, feebly carinate medially behind an anterior depression. *Antenna* three-fourths as long as body, fairly slender; scape stout, nearly twice as long as second segment; third to sixth slender; fourth distinctly longer than third, and a little longer than sixth; last longest. *Prothorax* four-fifths as long as broad, seven-tenths as broad as elytra, somewhat evenly rounded at side, nearly as broad at apex as at base; disc slightly uneven, with a low swelling at each side just anterior to center, finely punctured, with roughly 20 punctures in an approximate median row. *Scutellum* "U"-shaped, slightly broadened at base. *Elytron* more than twice as long as prothorax, suboblong, narrowed apically; disc with eight regular puncture-rows above, with an extra scutellar row, and three to five partly irregular rows at side; punctures mostly almost as wide as interspaces longitudinally, but much narrower than interstices transversely. *Ventral surfaces* feebly and irregularly punctured. *Legs* long; hind femur exceeding elytral apex. Length 3.6 mm.; breadth 1.7 mm.

Fig. 29. *Demotina fragilis* Gressitt, n. sp., aedeagus.

Viti Levu: Holotype, male (Bishop 2436), Nandarivatu, 900 m., beating shrubs, Sept. 1, 1938, Zimmerman. Allotype, female (Bishop), Lami Quarry, 50 m., near Suva, July 24, 1938, Zimmerman. Sixteen paratypes: Nandarivatu, Sept. 7–8, Tholo-i-suva, July 27, Belt road, 25 km. west of Suva, July 22, 1938, Zimmerman; Bulu, near Sovi, Apr. 21, 1941, Krauss; Lami Quarry, May 1951, Krauss; Naivithula, Tailevu, Aug. 18, 1937, Valentine.

Ovalau: Draiba trail, July 8, Wainiloka, 60 m., July 11, 1938, Zimmerman.

Vanua Levu: Daku road, east of Lambasa, three on *Alphitonia* and one on *Commersonia*, Oct. 6, 1955, Gressitt; Nakawanga, Oct. 9, 1955, Gressitt.

Hosts: *Alphitonia zizyphoides* (Spreng.) A. Gray; *Commersonia bartramia* (L.) Merr.

Differs from *D. veitchi* Bryant in being more slender, with the body less than one-half as broad as long, in having the legs longer, with the hind femur exceeding the elytral apex, the pronotum more even, and with the elytron less distinctly banded postmedially.

76. *Demotina nodosa* Bryant, n. sp.
Fig. 30*a*, *b*

Oblong, cylindrical, plum-brown, a paler transverse band behind middle of elytron, and apex paler; prothorax with two blunt tubercles on vertex, clothed with golden pubescence; elytron with shorter adpressed pubescence.

Head plum-brown, clothed with fine scattered golden pubescence, a longitudinal carina extending from between eyes to base. *Antenna* long and slender, extending almost to middle of elytron; first segment more dilated and twice as long as second; third slender and

twice as long as second; third to sixth each long and slender; remainder to apical segment slightly thickened and more pubescent, basal portion of each segment slightly fuscous. *Prothorax* plum-brown clothed with golden pubescence, widest just behind middle, and contracted in front, two blunt tubercles on vertex. *Scutellum* plum-brown, impunctate, rounded at apex. *Elytron* plum-brown, a transverse paler band behind middle, and apex paler; sides parallel and rounded at apex, punctate-striate, clothed with short adpressed golden pubescence. *Legs* with central portion of femora darker; tibiae with apical and basal portions darker. *Underside* fuscous, clothed with scattered pubescence; first ventral segment of abdomen longest. Length 5–5.5 mm.

VITI LEVU: Holotype (BISHOP 2437), Nandarivatu, Sept. 2, 1938, Kondo, one specimen. Nandarivatu, Navai Mill, Oct. 13, 1937, Valentine, four specimens. Nandarivatu, 1100 m., Sept. 3, 1938, Zimmerman, two specimens. Navai-Nasonga trail, Sept. 12, 1938, Zimmerman, three specimens; Mt. Victoria, 950 m., Sept. 16, 1938, Zimmerman.

A very distinct species, on account of the tuberculate prothorax.

77. *Demotina rugosata* Gressitt, n. sp.
Fig. 30*c*

Reddish brown to pitchy black, paler in part: head reddish brown, blackish on posterior portion of occiput; antenna ochraceous basally, pitchy on third to seventh segments, brown on remainder; prothorax reddish brown, largely pitchy to blackish at side; scutellum black; elytron dull reddish brown, with some of raised areas blackish and some of the lesser ones reddish or paler; ventral surfaces reddish brown, partly pitchy on first and last abdominal sternites; legs testaceous with femora black preapically, reddish apically, and tibiae partly pitchy subbasally and preapically. Dorsum somewhat irregularly and feebly clothed with minute goldish scales and a few erect hairs; ventral surfaces with a very few fine subrecumbent hairs.

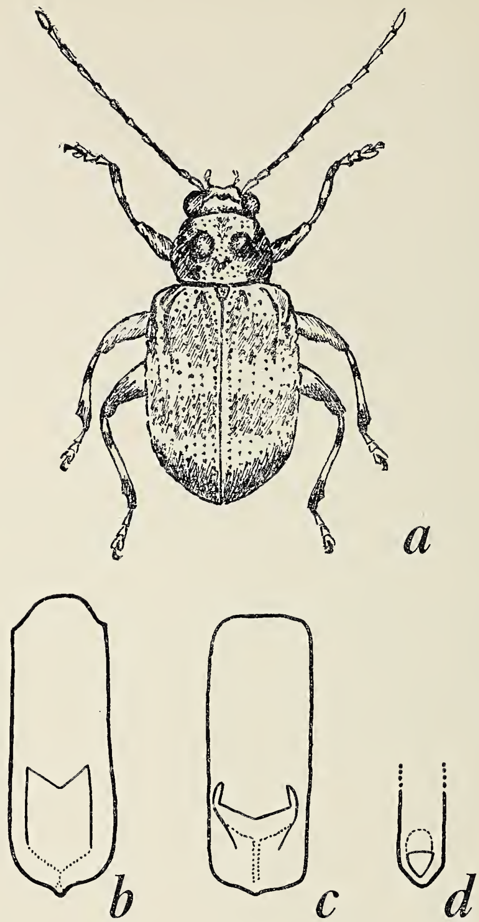

FIG. 30. *a*, *Demotina nodosa* Bryant, n. sp., type; *b*, *Demotina nodosa*, aedeagus; *c*, *Demotina rugosata* Gressitt, n. sp., aedeagus; *d*, *Demotina cylindricollis* Gressitt, n. sp., aedeagus.

Head slightly more than three-fourths as broad as prothorax, deeper than wide, distinctly punctured on the shiny frontoclypeus, more closely and finely punctured, and medially carinate, on the duller occiput. *Antenna* two-thirds as long as body, rather slender; scape nearly twice as long as second segment, barely longer than third; fourth slightly longer than third; fifth barely shorter than fourth,

longer than sixth; seventh to tenth stouter, about as long as sixth; last longer, suddenly narrowed before apex. *Prothorax* nearly as long as broad, two-thirds as broad as elytra, somewhat irregularly rounded at side; disc distinctly irregular, with an oblique raised area on each side of midline anterior to center, preceded anteriorly by an obtuse depression and slightly raised area on midline not far from apex; disc deeply impressed with longitudinal elliptical punctures, mostly more widely separated transversely than their widths; side very coarsely foveate- to reticulate-punctate. *Scutellum* narrowed, obtuse apically, convex. *Elytron* twice as long as prothorax, subrectangular, strongly rugose-punctate, for most part rather irregularly so, with two or three extra scutellar rows; disc with three distinctly raised areas in a rough line somewhat parallel to suture, near base, middle, and top of apical declivity, respectively, and also many other lesser nodes, ridges, or generally irregularly raised interstices. *Ventral surfaces* nearly impunctate. Length 4 mm.; breadth 2.2 mm.

PARATYPES: Length 3.5–4.2 mm.; breadth 1.8–2.2 mm.

VANUA LEVU: Holotype, female (BISHOP 2438), Nakawanga, alt. 80 m., on *Trichospermum*, Oct. 9, 1955, Gressitt. Six paratopotypes (one BM), same data, except two on *Macaranga* (probably by chance), Gressitt.

OVALAU: One, Andubangda, 500 m., July 15, 1938, Zimmerman.

VITI LEVU: Two, Belt road, 15–25 km. west of Suva, July 22, 29, 1938, Zimmerman; two, Lami, Mar. 1951, Krauss.

HOST: *Trichospermum calyculatum* (Seem.) Burret.

Differs from *D. nodosa* Bryant in being darker, in having the elytron much more irregular, with distinct tubercles and strong rugosity, and with the pronotum armed with a pair of widely spaced low oblique tubercles, instead of a pair of fairly close, conical tubercles.

78. *Demotina cylindricollis* Gressitt, n. sp.

Fig. 30*d*

Testaceous; prothorax slightly reddish ochraceous; antenna pale ochraceous, becoming slightly pitchy by last segment; elytral epipleuron and mesepimeron slightly pitchy reddish. Body clothed above with minute sparse golden scale-hairs, and on antenna with longer sparse oblique hairs; ventral surfaces nearly glabrous.

Head not quite as broad as prothorax, about as broad as deep; frontoclypeus very short, partly punctured; occiput finely and closely punctured; antennae almost as widely separated as eyes. *Antenna* nearly three-fourths as long as body; scape stout, a little longer and a little thicker than second segment; third to fifth slender, subequal; sixth barely shorter than fifth; seventh to tenth subequal, moderately stout; last longer, with apex more slender and set off. *Prothorax* nearly as long as broad, just over three-fifths as broad as elytra, feebly convex at side, fairly even above; disc finely punctured, with roughly 25 punctures in an approximate median row. *Scutellum* slightly longer than broad, widened at base, slightly convex apically, granulose. *Elytron* more than twice as long as prothorax, suboblong, narrowed apically; disc in part regularly punctured, with eight distinct puncture-rows above, behind middle, but about three extra, partly confused, scutellar rows, and four to six rows on lateral declivity; punctures mostly about as wide as interspaces longitudinally, but more widely separated between rows, at least in posterior two-thirds. *Ventral surfaces* nearly impunctate, except for bordering grooves of thoracic sternites and last abdominal sternite. Hind femur moderately stout, not reaching apex of abdomen. Length 2.4 mm.; breadth 1.25 mm.

PARATYPES: Some vague mottling on part of elytron. Length 2.3–2.5 mm.; breadth 1.1–1.3 mm.

VITI LEVU: Holotype (BISHOP 2439), west slope, Mt. Victoria, 950 m., Tholo North,

Sept. 16, 1938, Zimmerman. Two paratypes, ridge west of Nandarivatu, 850 m., Sept. 9, 1938, Zimmerman; one, Mavai, Sept. 1950, Krauss.

Two additional specimens, Nandarivatu, 1000 m., Sept. 6, 1938, Zimmerman, and Daku road, east of Lambasa, Vanua Levu, Oct. 6, 1955, Gressitt, appear to represent two different, related species. The former has the prothorax fully as long as broad, but in the latter it is broader and more rounded at side.

Differs from *D. fulva* Bryant in being smaller, more finely punctured, and with the prothorax longer and less rounded at side. This species probably represents a different genus.

Genus DAMELIA Clark

Damelia Clark, 1864, Jour. Ent. 2: 255 (type: *D. marshalli* Clark; Fiji); Chapuis, 1874, Gen. Col. 10: 271; Lefevre, 1885, Soc. Sci. Liege, Mem. Ser. 2, 11: 72.

Head small; last maxillary palpal segment acuminate; eye large. Antenna filiform, three-fourths as long as body, with scape swollen, second and third subequal, following longer and last shorter and stouter. Prothorax cylindrical, nearly as long as broad, dilated in middle, lateral border wanting, and surface irregular. Elytron broad, subquadrate, rounded apically, irregular, punctured and rugose-tuberculate.

KEY TO FIJIAN SPECIES OF *Damelia*

1. Color deep metallic or bronzy black. . . . 2
   Color purplish black to greenish black; pronotal punctures coarse. . . . . **marshalli**
2. Elytron with close pubescence; legs with long pubescence; bronzy black. . . **rugosa**
   Elytron with scattered pubescence; legs with short pubescence; deep metallic brown. . . . . **verrucosa**

79. Damelia marshalli Clark

Damelia marshalli Clark, 1864, Jour. Ent. 2: 256 (Fiji; type in Brit. Mus.); Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 482.

Greenish black to purplish black, shiny. *Head* closely and in part confluently punctured; *antenna* distinctly thickened distally; *prothorax* slightly narrower than elytra, rounded at side, densely punctured and bearing three tubercles; *elytron* strongly and densely punctured and with somewhat oblong tubercles. Length 5 mm.; breadth 2.5 mm.

VITI LEVU: Presumably Viti Levu, though locality not specified. Lacking in present collection.

80. *Damelia verrucosa* Bryant, n. sp.
Fig. 31

Deep metallic brown, antenna and tibiae fulvous; rugosely punctured, prothorax with two large median blunt tubercles, and four small ones near side margin; elytron irregularly verrucose.

Head strongly punctured, a smooth longitudinal carina from between eyes to base;

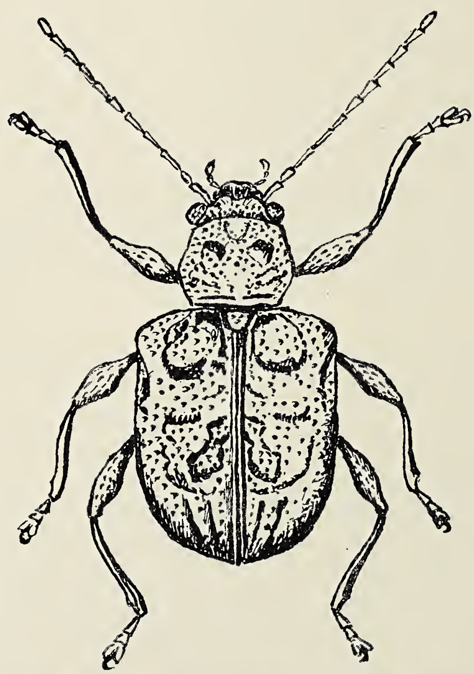

FIG. 31. *Damelia verrucosa* Bryant, n. sp., type.

not as broad as prothorax; clypeus and palpi flavous. *Antenna* fulvous, extending to middle of elytron; five basal segments fulvous and more glabrous than six apical segments, which are more fuscous; first segment more dilated and slightly longer than second. *Prothorax* deep metallic brown, side slightly rounded, rugosely punctured, two large median blunt tubercles, and two small ones near anterior half of side margin. *Scutellum* deep metallic brown, impunctate. *Elytra* deep metallic brown, much broader than base of prothorax, rounded at apex, strongly and irregularly punctured, and verrucose. *Legs* with femora dilated in middle, slender at base, strongly punctured, and with scattered pubescence; tibiae and tarsi more fulvous. *Underside* with ventral segments of abdomen tinged with fulvous, first segment equal to second and third together. Length 5–6 mm.

VITI LEVU: Holotype (BISHOP 2440), ridge west of Nandarivatu, 900 m., Apr. 13, 1937, Valentine. Six paratypes, Nandarivatu, 1000 m., Sept. 3, 1938, beating shrubbery, Zimmerman; Navai Mill, Nandarivatu, Oct. 13, 1937, Valentine.

OVALAU: Thawathi, 180–270 m., June 12, 1938, beating shrubbery, Zimmerman.

Allied to *D. marshalli* Clark, but differing in sculpture, and without any purple reflections, duller brown.

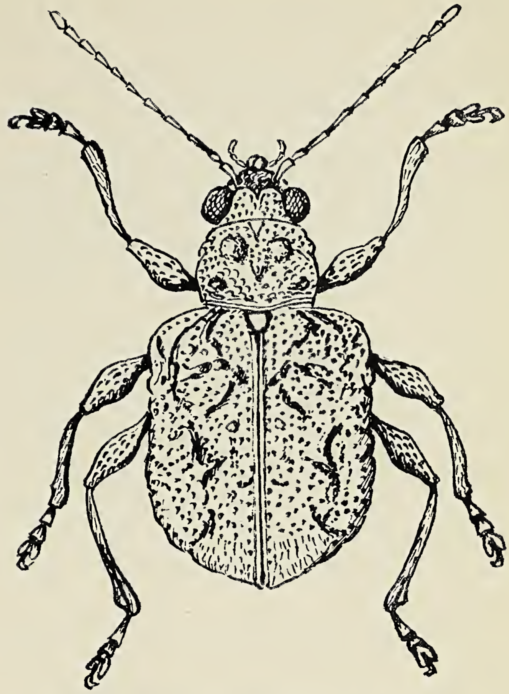

FIG. 32. *Damelia rugosa* Bryant, n. sp., type.

81. *Damelia rugosa* Bryant, n. sp.
Fig. 32

Bronzy black; antenna, labrum, palpi, and basal portions of femora and tibiae fulvous. Prothorax and elytron very rugose and irregularly punctured.

Head bronzy black, strongly and closely punctured, as broad at eyes as front of prothorax; labrum and palpi fulvous. *Antenna* fulvous, extending to middle of elytron; first segment more dilated, slightly longer than second; second shorter than third; fourth slightly longer than third, and equal to fifth; third to fifth elongate and more slender than six apical segments, which are slightly thickened. *Prothorax* much narrower than base of elytra, bronzy black, very rugose, strongly and closely punctured, widest behind middle, two blunt tubercles on disc and a small one near posterior angle. *Scutellum* bronzy black, its apex rounded. *Elytron* bronzy black, rugose and verrucose, irregularly punctured, rounded at apex; apical portion clothed with scattered pale pubescence. *Legs* bronzy black; femora with median portions swollen, strongly punctured and pubescent, basal portions narrow and fulvous; tibiae and tarsi more or less fulvous and clothed with pale pubescence. *Underside* bronzy black; ventral segments of abdomen pubescent. Length 5–6 mm.

VITI LEVU: Holotype (BISHOP 2441), Tholo-i-suva, July 25–27, 1938, Zimmerman, beating shrubs; four specimens (one paratype in BM).

Allied to *D. marshalli* Clark, but differs in its more bronze color, in the sculpture of the prothorax and the elytra, and in the closer puncturation.

Tribe COLASPOIDINI

(IPHIMEINI and ENDOCEPHALINI)

Genus EUCOLASPIS Sharp

Eucolaspis Sharp, 1886, Roy. Dublin Soc., Trans. Ser. 2, 3: 445 (type: here designated as *Colaspis pallidipennis* White; New Zealand); Broun, 1893, Manual N. Zealand Col. 5: 1303.

Head small, rounded, engaged in prothorax; eyes widely separated. Antenna as a rule dilated at apex. Prothorax as broad at its base as elytra, or a little less broad, its side margin well marked and entire. Elytron ovate or briefly ovate, seldom oblong. Prosternum truncate, square at base. Legs simple, tibia of the posterior pair not emarginate; claws appendiculate.

A New Zealand species is a pest of apple trees.

KEY TO FIJIAN SPECIES OF *Eucolaspis*

1. Testaceous, rarely with borders of elytron blackish; elytral interstices impunctate. . . . . **castanea**

   Reddish to pitchy, with suture and outer margin black; elytral interstices micropunctulate . . . . **saltator**

82. *Eucolaspis castanea* Bryant, n. sp.

Fig. 33*a*, *b*

Entirely castaneous, or with varying degrees of black on prothorax and elytron, head and prothorax impunctate, elytron finely punctate-striate.

Head castaneous, impunctate, with eyes as wide as front of prothorax. *Antenna* flavous, or in some with seven apical segments tinged with fuscous; two basal segments more dilated, first about twice as long as second; third to sixth long and slender; seventh to apex slightly thickened; extending to middle of elytron. *Prothorax* castaneous, or with varying degrees of black to entirely black, nitid, impunctate, narrowly margined all round, widest at base, gradually contracted to apex. *Scutellum* castaneous, impunctate. *Elytron* entirely castaneous or with side margins and suture fuscous, punctate-striate, widest at base, gradually tapering and rounded at apex. *Legs* castaneous, tibiae all straight and not emarginate apically. *Ventral surfaces* castaneous; first ventral segment of abdomen longest; second to fourth equal to each other. Length 2.6–3.3 mm.; breadth 1.9–2.1 mm.

VITI LEVU: Holotype (BISHOP 2442), Nandarivatu, Oct. 7, 1937, on *Scaevola*, Valentine; 14 paratopotypes, Valentine; six paratopotypes, 1100 m., Sept. 10, 1938, Zimmerman. One paratype, Mt. Victoria, Sept. 16, 1938, Zimmerman; one, Mt. Korombamba, Aug. 1, 1938, Zimmerman; ten, Lami Quarry, near Suva, Feb. and May 1951, Krauss.

HOST: *Scaevola floribunda* A. Gray.

83. *Eucolaspis saltator* Gressitt, n. sp.

Fig. 33*c*

MALE: Ochraceous, heavily marked with pitchy on inner portion, and outer margin, of elytron; antenna and legs testaceous.

Head rather even, with some strong punctures between eyes. *Antenna* slender, as long as body; scape swollen, twice as long as second segment; third nearly as long as scape, subequal to fourth; fifth and following slightly longer. *Prothorax* nearly twice as broad as long, nearly as broad as elytra, evenly convex, moderately rounded at side, with scattered large punctures and minute punctures between them. *Scutellum* rounded-triangular. *Elytron* widest just behind humerus, subevenly rounded, with nine rows of fine punctures, besides scutellar row. *Ventral surfaces* smooth, nearly impunctate, with a few suberect hairs, mostly on first abdominal sternite. Length 2.5 mm.; breadth 1.65 mm.

PARATYPES: Length 2.3–3.2 mm.; breadth 1.45–2.2 mm.

VANUA LEVU: Holotype, male (BISHOP 2443), between Navakuru and Nakawanga, 100 m., central Vanua Levu, on *Tarenna*, Oct.

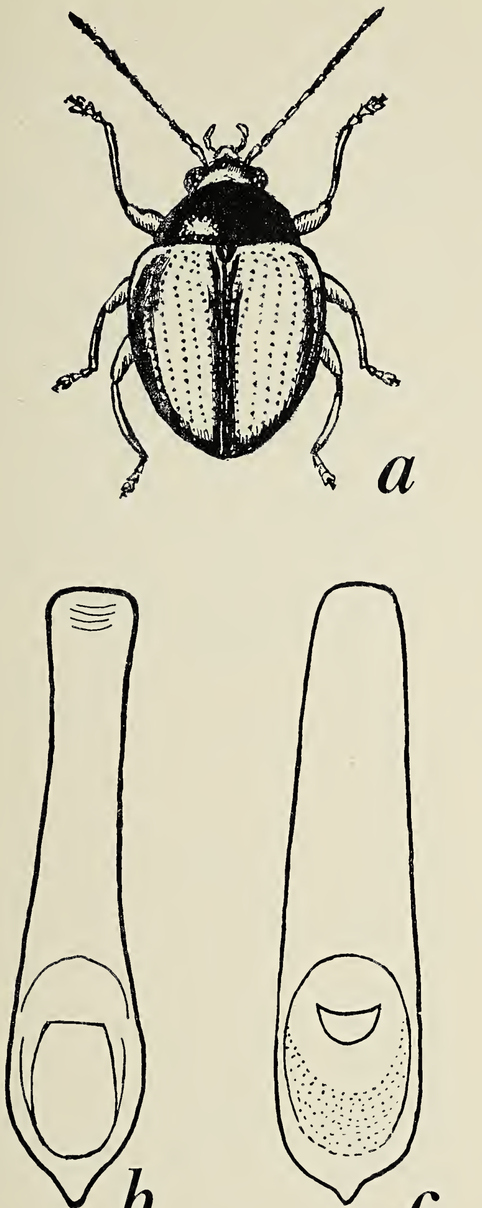

FIG. 33. *a*, *Eucolaspis castanea* Bryant, n. sp., type; *b*, *Eucolaspis castanea*, aedeagus; *c*, *Eucolaspis saltator* Gressitt, n. sp., aedeagus.

7, 1955, Gressitt; allotype, female (BISHOP), same data. Ten paratypes (BISHOP, BM, US, CSIRO): eight paratopotypes, mostly on *Tarenna*, same data; one, Navakuru, light trap, Oct. 6; one, Daku road, 12 km. east of Lambasa, on *Commersonia*, Oct. 6, 1955, Gressitt.

HOSTS: *Tarenna sambucina* (Forst.) Durand; *Commersonia bartramia* (L.) Merr.

Differs from *E. castanea* Bryant in being darker, in part blackish, with the head and pronotum more heavily punctured, the elytron micropunctulate between puncture-rows. This species was observed to jump.

Genus COLASPOIDES Laporte

Colaspoides Laporte, 1833, in Silberm. Rev. d'Ent. 1: 20 (type: *Cryptocephalus limbatus* Fabr.; S. America); Baly, 1864, Ent. Monthly Mag. 1: 134; 1867, Ent. Soc. London, Trans. (3) 4(2): 134; Chapuis, 1874, Gen. Col. 10: 346; Jacoby, 1908, Fauna of India, Chrys. 1: 514.

Head broad; antenna long and slender; prothorax nearly as broad as elytra basally, narrowed anteriorly, margined at side; elytron subregularly punctured; femora sometimes toothed beneath; claws appendiculate.

KEY TO FIJIAN SPECIES OF *Colaspoides*

1. Pronotum distinctly convex, distinctly narrowed anteriorly; breadth of body generally less than 2.5 mm. 2

   Pronotum feebly convex, sparsely punctured; sides of prothorax nearly parallel in basal half; breadth of body generally at least 3 mm.; pitchy brown with a metallic tinge . . . . **vitiensis**

2. Pale reddish brown, sometimes darker on pronotum, which is sparsely punctured; aedeagus of male deeply emarginate at middle of apex . . . . **brunnea**

   Pitchy brown to dark reddish brown; pronotum more densely punctured, sometimes with interspaces hardly more than twice as wide as punctures; aedeagus of male with a strong blunt tooth at middle of apex . . . . **confusa**

84. *Colaspoides brunnea* Bryant, n. sp.
Fig. 34*a*, *b*

Entirely pale brown; head coarsely punctured; prothorax irregularly and not closely punctured, elytron irregularly punctate-striate.

Head pale brown, coarsely punctured, labrum and clypeus smooth. *Antenna* pale brown, extending slightly beyond middle of elytron; first segment more dilated and twice as long as second; third about three times as long as second; third to last all about equal, slightly pubescent. *Prothorax* pale shining brown, very transverse, side feebly margined, rounded in front, irregularly and not closely punctured; basal portion smooth, with a row of punctures along basal margin. *Scutellum* brown, impunctate. *Elytron* pale brown, widest at base, gradually tapering to apex, irregularly punctate-striate, the punctures slightly stronger than on prothorax. *Legs* pale brown; tibiae clothed with pale pubescence; femora unarmed. *Underside* pale brown; ventral segments of abdomen feebly punctured. Length 5 mm.

OVALAU: Holotype (BISHOP 2444), Wainiloka, Sept. 28, 1937, Valentine, nine specimens.

VITI LEVU: Naivithula, Sept. 28, 1937, Valentine, one specimen; Lami Quarry, near Suva, May 1951, Krauss; Suva, Feb. 1952, Gressitt.

Allied to *C. vitiensis* Bry., and *C. tarsalis* Lea., but differs in its pale color without metallic gloss.

85. *Colaspoides confusa* Gressitt, n. sp.
Fig. 34*c*

Reddish brown; antenna and legs testaceous. Body glabrous above; ventral surfaces and legs with sparse fine oblique hairs.

Head nearly four-fifths as broad as prothorax, about as broad as deep, sparsely punctured, most densely so near antennal insertions; frontoclypeus concave in center. *Antenna* slender, two-thirds as long as body; scape three times as long as second segment; third subequal in length to scape and fourth; fifth distinctly longer, subequal to each of following. *Prothorax* about twice as broad as long, nearly as broad as elytra, subrectangular, moderately narrowed anteriorly, feebly obtuse in basal outline; disc moderately convex, with

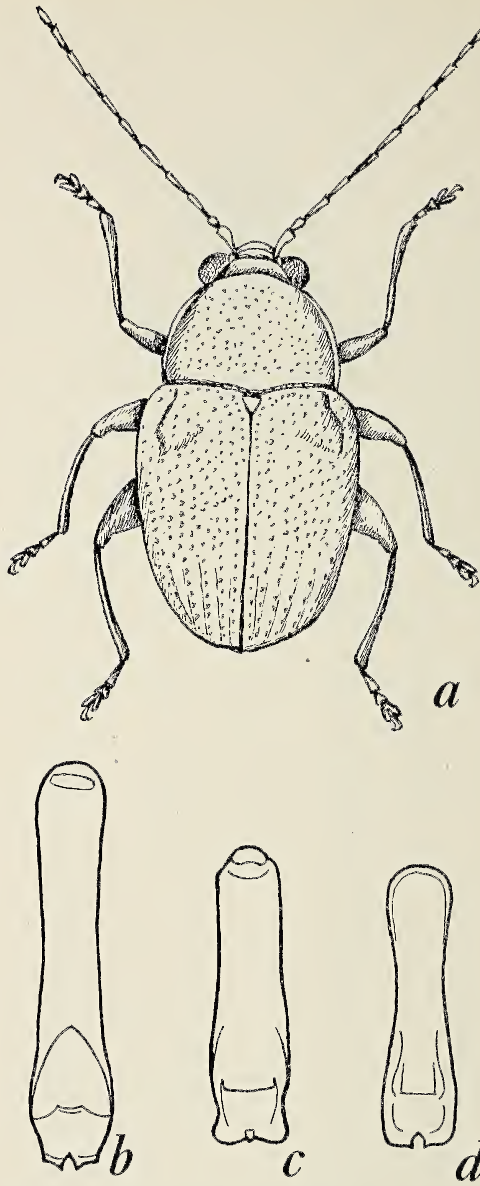

FIG. 34. *a*, *Colaspoides brunnea* Bryant, n. sp., type; *b*, *Colaspoides brunnea*, aedeagus; *c*, *Colaspoides confusa* Gressitt, n. sp., aedeagus; *d*, *Colaspoides vitiensis*, aedeagus.

fairly numerous distinct punctures, some separated by as little as twice the diameter of a puncture. *Scutellum* rounded-triangular, finely frosted. *Elytron* three times as long as prothorax, somewhat deeply punctured in more than ten very irregular rows. *Ventral surfaces* finely punctured. Length 4.5 mm.; breadth 2.35 mm.

PARATYPES: Mostly pitchy castaneous with a slight metallic sheen. Length 3.9–4.7 mm.; breadth 2.1–2.7 mm.

VITI LEVU: Holotype, male (BISHOP 2445), hill behind Suva, 100 m., Feb. 6, 1952, Gressitt; allotopotype, female, same data; one paratopotype, same data; 48 paratypes (BISHOP, BM, US, CSIRO), Lami Quarry, May 1951, Mar. 1955, Krauss; one, Vuti Dawa, Aug. 27, 1925, W. H. Ford; one, Belt road, 25 km. west of Suva, July 22, 1938, Zimmerman; one, 6 km. south of Nandarivatu, 700 m., Sept. 9, 1938, Kondo.

There is one doubtful specimen from Tuvutha, Lau, Sept. 10, 1924, Bryan, and another from Navai Mill, near Nandarivatu, Sept. 17, 1938, Zimmerman.

Differs from *C. vitiensis* and *C. brunnea* in having the aedeagus of male distinctly toothed, instead of deeply emarginate, at middle of apex, and in having the pronotum more closely punctured.

86. **Colaspoides vitiensis** Bryant

Fig. 34*d*

Colaspoides vitiensis Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 250 (Makongai and Viti Levu; type in Brit. Mus.).

Reddish brown with metallic gloss; antenna and legs slightly paler. *Head* distinctly punctured, more closely so between eyes; *antenna* extending a little beyond middle of elytron; *prothorax* very convex, with large irregularly distributed punctures; *scutellum* impunctate, subtriangular; elytra with not very dense, but rather large punctures, becoming smaller and in regular striae posteriorly; femora unarmed. Length 4.5 mm.

VITI LEVU: Tamavua; Nausori. Mt. Victoria, west slope, 950 m., Tholo North, Nandarivatu, 1100 m., Navai Mill, Sept., Tholo-i-suva, July 1938, Zimmerman; Navai Mill, Oct. 1937, Valentine; Lami, Mar. 1955, Krauss.

OVALAU: Wainiloka, Sept. 1937, Valentine.

VANUA LEVU: Nakawanga, on *Phaleria*, Oct. 1955, Gressitt.

CENTRAL FIJI: Makongai I. (type locality).

LAU: Tubutha I., Sept. 1924, Bryan.

HOST: *Phalaeria acuminata* (A. Gray) Gilg.

Subfamily *CHRYSOMELINAE*

Genus PLAGIODERA Redtenbacher

Plagiodera Redt., 1845, Gatt. Deutsch. Käferf.: 116 (type: *Chrysomela versicolora* Laicharting (*armoraciae*, Redt. *nec*. Linn.); Europe, Asia).

Roundish, convex; metallic. Head broad; antenna short; prothorax transverse, oblique at side, emarginate anteriorly; elytron irregularly punctured in large part; epipleuron broad; tarsal claws simple.

87. **Plagiodera violaceipennis** Bryant

Plagiodera violaceipennis Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 594 (Natova; Ovalau; type in Brit. Mus.).

Fulvous with antenna darker distally, elytron metallic bluish purple. *Head* longitudinally impressed between eyes; *antenna* with scape longer than second segment and about equal to third, last seven segments more flattened and subequal; *prothorax* smooth and shiny, more than twice as broad as long; *elytron* finely and irregularly punctate, broadest behind middle, apical angle produced into a minute tooth, lateral border slightly flattened and reflexed, humeral callus strongly marked, base slightly depressed; central portions of abdominal sterna smooth and shiny, with sides unevenly punctured, last sternite slightly notched. Length 8 mm.

VITI LEVU: Natova (type locality).

OVALAU: (type series).

VANUA LEVU: Nakawanga and Navukuru, Oct. 1955, Gressitt; five specimens.

MAKONGAI: May 1941, Lever; several specimens.

LAU: Yathata, Oct. 1924, Bryan; 60 specimens.

Subfamily *GALERUCINAE*

KEY TO FIJIAN GENERA OF GALERUCINAE

1. Elytral epipleuron narrow from before middle (or pronotum irregular and elytron shorter than abdomen); anterior coxal cavity open behind; pronotum transversely grooved or irregular....2

   Elytral epipleuron gradually narrowed; anterior coxal cavity closed behind; pronotum convex, or broadly and evenly concave, but not narrowly grooved across middle.....................5

2(1). Elytral epipleuron gradually narrowed 3

   Elytral epipleuron suddenly narrowed anterior to middle; tarsal claws bifid; pronotum with a slightly sinuate groove...............**Aulacophora**

3(2). Elytron entire; hind wing present; pronotum transversely grooved........4

   Elytron shorter than abdomen; hind wing absent; pronotum irregular; tarsal claws bifid.................**Khasia**

4(3). Antenna simple in male, slender..... ....**Haplosomoides**

   Antenna stout, with sixth, seventh, or eighth segments enlarged in male.... ....**Cerophysa**

5(1). First hind tarsal segment much shorter than one-half tibial length.........6

   First hind tarsal segment about one-half as long as tibia......**Metrioidea**

6(5). Tarsal claws bifid; pronotum broadly concave..............**Malacotheria**

   Tarsal claws appendiculate; pronotum convex, with one or two slight depressions on side of disc....**Plesistia**

Tribe OIDINI

Genus AULACOPHORA Duponchel and Chevrolat

Aulacophora Duponchel and Chevrolat, 1842, IN d'Orbigny, Dict. Univ. Hist. Nat. 2: 337 (type: *Galleruca quadraria* Olivier; Europe); Maulik, 1936, Fauna of India, Col. Chrys. Galeruc., 169.

Raphidopalpa, *Rhaphidopalpa*, *Ceratia*, *Orthaulaca*. (See Gressitt, 1955, Insects of Micronesia 17(1): 22 for fuller synonymy.)

Body fairly broad; antenna slender, sometimes with some segments broadened in males; pronotum with a sinuous or transverse groove across disc just behind middle.

KEY TO FIJIAN SPECIES OF *Aulacophora*

1. Elytron unicolorous, yellow or black; prothorax obtusely rounded at side.......2

   Elytron pale marked with a large basal and a large subapical black area, the former nearly reaching suture; prothorax subangulate at side........**quadrimaculata**

2. Dorsum entirely testaceous to reddish testaceous; elytron distinctly broadened behind middle.................**similis**

   Elytron black, shiny, suboblong, hardly broadened behind middle....**nigrivestis**

88. **Aulacophora nigrivestis** (Boisduval)

Galleruca nigrivestis Boisduval, 1835, Voyage Astrolabe, Col.: 548 (New Holland; type in Paris Mus.).

Aulacophora nigrivestis, Allard, 1889, Soc. Ent. de France, Ann. 57: 310; Baly, 1889, Ent. Soc. London, Trans. 1889: 301.

Ceratia (*Orthaulaca*) *nigrivestis*, Weise, 1924, Coleopt. Cat. 78: 15.

Testaceous; elytron shiny black; abdomen black except for extreme apex; antenna ochra-

ceous with third to eighth segments pitchy. Antenna slender; prothorax broadest one-third its length from apex, but not angulate at side, the disc with a broad slightly obtuse groove just behind middle; elytron finely punctured. Length 9–9.5 mm.; breadth 4.4–4.8 mm.

VITI LEVU: Nandarivatu, 700 m., Nov. 1940, Degener; Nandarivatu, 800 m., at light, Sept. 6–8, 1938, Zimmerman.

89. **Aulacophora quadrimaculata** (Fabricius)

Crioceris quadrimaculata Fabr., 1781, Spec. Ins. 1: 152 ("Cape of Good Hope"; type in Brit. Mus.).

Aulacophora quadrimaculata Maulik, 1929, *Insects of Samoa* 4(3): 194; Veitch and Greenwood, 1921, Linn. Soc. N. S. Wales, Proc. 46: 511; Lever, 1942, Agr. Jour. [Fiji] 13(2): 48; Gressitt, 1955, *Insects of Micronesia* 17 (1): 26.

Galleruca austrocaledonica Montrouzier, 1861, Soc. Ent. de France, Ann. 4(1): 299 (New Caledonia).

Aulacophora tetrastictoptera Lea, 1924, Queensland Mus., Mem. 8: 50.

Testaceous, slightly more ochraceous on pronotum, marked with black on hind portion of head, except median line, with a large basal and a large subapical black area on elytron; ventral surfaces with most of metasternum and abdomen black. Antenna with third segment slightly thickened distally in male; prothorax sinuate at side, broadest and subangulate anterior to middle, with disc finely and irregularly punctured and with a slightly sinuate, shallow, transverse groove just behind center; elytron finely punctured. Length 4.6–7 mm.; breadth 2.3–3.4 mm.

YASAWA: Yalobi, Waya I., July 1937, St. John.

VITI LEVU: Lowlands.

OVALAU: Andubangda, July 1938, Zimmerman.

LAU: Vanua Mbalavu, Sept. 1924, Bryan; Wailangilala, Sept. 1924, Bryan; Oneata, Aug. 1924, Bryan.

KANDAVU: Wai Salima, Ndavingeile, and Kaivala, Apr. 1941, Krauss.

HOSTS: *Citrullus vulgaris* Schrad., *Cucurbita pepo* DC, and other cucurbits.

90. **Aulacophora similis** (Olivier)
Fig. 35

Galeruca similis Olivier, 1808, Entomologie 6: 624, no. 93, pl. 2, fig. 23 (E. Indies).

Orthaulaca similis, Weise, 1892, Deutsche Ent. Zeitschr. 1892: 393.

Aulacophora fabricii, Knowles, 1907, Legislative Council Paper, Fiji, No. 13, Report for 1906; Jepson, 1911, Fiji Dept. Agr., Council Paper 25: 58.

Aulacophora argyrogaster, Veitch and Greenwood, 1921, Linn. Soc. N. S. Wales, Proc. 46: 511.

Aulacophora similis, Maulik, 1929, *Insects of Samoa* 4(3): 192; Gressitt, 1955, *Insects of Micronesia* 17(1): 28, fig. 8.

? *Aulacophora coffeae*, Greenwood, 1940, Linn. Soc. N. S. Wales, Proc. 65: 215; Lever, 1942, Agr. Jour. [Fiji] 13(2): 48; Evans, 1952, Injur. Insects Brit. Commonwealth: 119.

MALE: Ochraceous; metathorax, abdomen (except end of last segment), and middle and hind legs black; antenna slightly brownish on

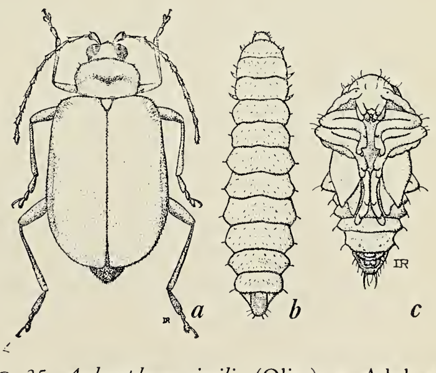

FIG. 35. *Aulacophora similis* (Oliv.): *a*, Adult male; *b*, larva, dorsal view; *c*, pupa, ventral view (Micronesian specimens, after Gressitt, 1955, *Insects of Micronesia* 17 (1): 29).

third to fifth segments, pitchy on remainder. *Head* slightly hairy and finely punctured anteriorly, smooth on occiput; *antenna* three-fourths as long as body, slender except for swollen and somewhat flattened scape; third and fourth segments oblique apically; prothorax subtrapeziform, broadest slightly behind apex, with a deep transverse depression which is widened and bent slightly backward at middle; *elytron* finely and irregularly punctured and with humeral area clothed with fine erect hairs; *last sternite* with a large concave oblong process with a deep narrow emargination on each side.

FEMALE: Antenna two-thirds as long as body; scape less swollen; pronotum less deeply grooved; humerus not pubescent; last sternite with a broad terminal emargination.

Length 6–7.5 mm.; breadth 2.6–3.6 mm.

YASAWA: Yalobi, Waya I., July 1937, St. John.

VITI LEVU: Nandi, June 1913, Illingworth; Nandovi, Singatoka, May 1915, Veitch; Waito, Tailevu, Sept. 1937, Valentine.

OVALAU: Levuka, July 1938, Zimmerman.

VANUA LEVU: Lambasa, Oct. 1955, Gressitt.

TAVEUNI: Ngathabula (Qacabula), on pumpkin, Nov. 1937, Valentine.

LAU: Ongea I., Oneata I., Komo I., Aug. 1924, Bryan.

CENTRAL FIJI: Matuku I., July 1924, Bryan; Naroi, Moala I., Aug. 1938, Zimmerman.

KANDAVU: Wai Salima, Apr. 1941, Krauss.

HOSTS: *Citrullus vulgaris* Schrad., *Cucurbita pepo* DC, *Cucumis melo* L., *C. sativus* L., and other cucurbits.

Knowles (1907) and Jepson (1911) reported *Aulacophora fabricii* Baly as damaging melons and pumpkins in Fiji. Lever (1942) reported *A. coffeae* in addition to *A. similis*, and stated that Knowles' record applies to *A. coffeae*. We have not been able to verify the records of *A. coffeae*.

Tribe GALERUCINI

Genus MALACOTHERIA Fairmaire

Malacotheria Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 486 (type here designated as *M. funerea* Fairm.; Fiji).

Head nearly as broad as prothorax; pronotum concave longitudinally, partly smooth; elytron finely and irregularly punctured, often carinate at side; antennal segments subequal, with second shorter.

The species below have been difficult to delimit. There are clearly at least three species, but perhaps more, for there is much variation within each series, and the material at hand does not seem to fit well with the original descriptions. This genus is found in Fiji and the Papuan subregion.

KEY TO FIJIAN SPECIES OF *Malacotheria*

1. Body less than twice as long as broad; elytron feebly carinate or not carinate. . . 2

   Body more than twice as long as broad; elytron distinctly carinate along side. . . . . **lateritia**

2. Pronotum largely smooth, subglabrous, black in center; elytron pale brown, with silvery pubescence . . . . **funerea**

   Pronotum pubescent, in part densely punctured; elytron dull with thin golden buff or silvery buff pubescence. . . . **strigiscuta**

91. **Malacotheria funerea** Fairmaire
Fig. 36*a*

Malacotheria funerea Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 487 (Viti; type in Paris Mus.).

Pale brown, pitchy on occiput, central portion of pronotum, and scutellum; pubescence silvery on elytron. *Head* slightly concave on occiput, feebly punctured; *antenna* with fourth and fifth segments longest; *pronotum* concave, smooth, feebly punctured, subglabrous; *elytron* finely and irregularly punctured, distinctly broadened behind middle. Length 6.7–7.7 mm.; breadth 3.5–4.1 mm.

VITI LEVU: Mt. Victoria and Nandarivatu, Sept. 1938, Zimmerman; seven specimens.

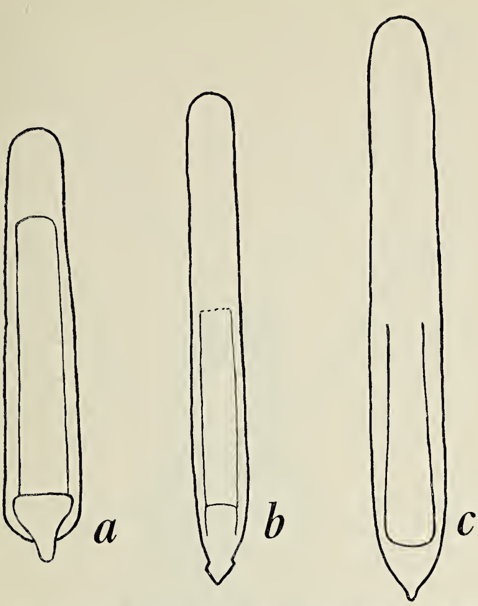

FIG. 36. *a*, *Malacotheria funerea*, aedeagus; *b*, *Malacotheria strigiscuta*, aedeagus; *c*, *Malacotheria lateritia*, aedeagus.

92. **Malacotheria strigiscuta** Fairmaire
Fig. 36*b*

Malacotheria strigiscuta Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 487 (Viti, Ovalau; type in Paris Mus.).

Pale brown, darker on occiput and center of pronotum; tibiae, tarsi, and antenna largely dull. *Head* concave on occiput; third antennal segment short; *pronotum* concave, distinctly punctured, pubescent, entirely pale or darkened only on center; *elytron* closely punctured, somewhat distinctly carinate at side. Length 6–7.2 mm.; breadth 2.8–3.4 mm.

VITI LEVU: Nandarivatu, Sept. 1938, Belt road, 70 km. west of Suva, July 1938, Zimmerman.

OVALAU: Thawathi, and Draiba trail, July 1938, Zimmerman.

Nine specimens.

93. **Malacotheria lateritia** Fairmaire
Fig. 36*c*

Malacotheria lateritia Fairm., 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 488 (Viti; type in Paris Mus.).

Brown, paler on prothorax and ventral surfaces, nearly black on head; antenna and legs pale, annulated with darker. *Head* generally somewhat concave on occiput; *pronotum* concave, somewhat punctured, pubescent, less acute at anterior angle than in preceding two species; *elytron* finely punctured, distinctly carinate at side. Body narrower than in preceding two species. Length 5.5–7 mm.; breadth 2–2.8 mm.

VITI LEVU: Nandarivatu, Navai Mill, and Korovou, Tailevu, Sept. 1937, Valentine; Nandarivatu, ridge west of Vatuthere, Sept., Belt road 70 km. west of Suva, July 1938, Zimmerman; Lami Quarry, near Suva, May 1951, Krauss.

OVALAU: Draiba trail, Thawathi, July 1938, Zimmerman.

VANUA LEVU: Nakawanga, on *Pipturus*, Oct. 1955, Gressitt.

Thirty-one specimens.

HOST: *Pipturus argenteus* var. *lanosus* Skottsb.

Genus PLESISTIA Maulik

Plesistia Maulik, 1929, Insects of Samoa 4(3): 198 (type: *P. brunnea* Maulik; Samoa, Fiji).

Antenna reaching middle of elytron, first and fourth segments long; prothorax transverse, side rounded, each angle with a seta; elytron with ten ribs including a short scutellar one, the suture raised and alternate ribs more strongly raised; fore coxal cavity closed; tarsal claw with angular projection at base.

94. **Plesistia brunnea** Maulik

Plesistia brunnea Maulik, 1929, Insects of Samoa 4(3): 199, figs. 10, 11 (Samoa, Fiji; type in Brit. Mus.).

Gray-brown; last eight antennal segments black above; legs pitchy distally. *Head* impunctate, grooved medially; scape long, clavate; second antennal segment shorter than third; *prothorax* flattened, with shallow depressions; *elytron* ribbed. Length 8 mm.

VITI LEVU: Thuvu (Cuvu). Korovou, Tailevu, Sept. 1937, Valentine; ten specimens.

Samoa (type locality).

There is some question as to whether the species was introduced from Samoa to Fiji, or vice versa.

Tribe LUPERINI

Genus HAPLOSOMOIDES Duvivier

Haplosomoides Duviv., 1890, Soc. Ent. de Belg., C. R. 34: XXXIV (type: *Rhaphidopalpa serena* Boheman; E. Indies).

Elongate; head larger than prothorax; antenna slender; prothorax trapeziform, wider at apex, constricted and transversely grooved; elytron long, swollen near scutellum, deeply punctured in center; tarsal claws appendiculate.

95. ***Haplosomoides binotata*** Bryant, n. sp.
Fig. 37

Narrow and elongate; head, antenna, prothorax, legs, and underside fulvous; elytron shining dark brown or blackish, with two median flavous patches, a fulvous stripe from the shoulder, and the suture narrowly fulvous not extending to the apex.

Head fulvous, nitid, impunctate, a transverse depression between eyes; eye somewhat prominent. *Antenna* fulvous, extending to middle of elytron, first segment longest, about three times as long as second; third to sixth about equal; third about twice as long as second; four apical segments each slightly shorter than sixth. *Prothorax* slightly transverse, fulvous; side margined and narrowly fuscous; anterior portion slightly broader than head; side margin contracted to base. *Scutellum* fulvous, large, triangular. *Elytron* elongate and narrow, feebly costate at side, slightly broadening to apex, which is rounded; dark shining brown with a median flavous patch, joined to shoulder by a fulvous stripe; suture narrowly fulvous not extending to apex, covered with large shallow punctures. *Legs* and underside fulvous; tarsus with first segment elongate, equal to remainder. Length 4 mm.

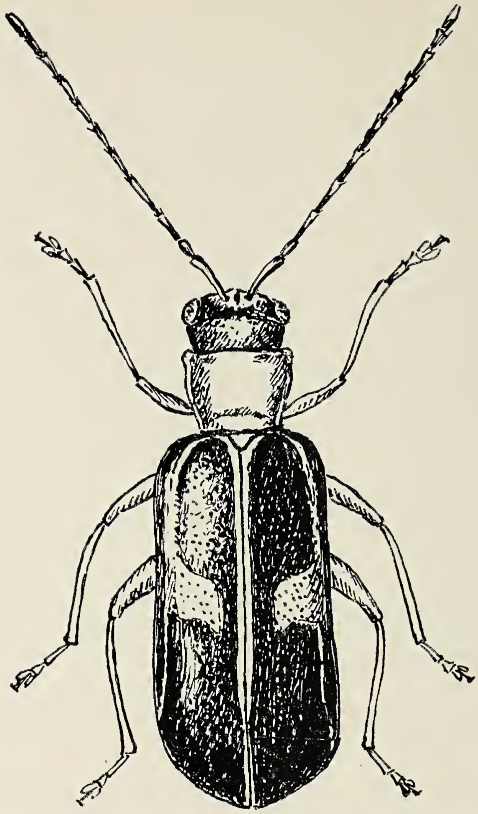

FIG. 37. *Haplosomoides binotata* Bryant, n. sp., type.

VITI LEVU: Holotype (BISHOP 2447), Nandarivatu, Sept. 6, 1938, 1100 m., Zimmerman; five specimens. Tholo-i-suva, July 25, 1938, Zimmerman; one specimen.

OVALAU: Andubangda, July 15, 1938, Zimmerman.

A very distinct species on account of its pattern. Allied to *Mimastra costata* Baly from Formosa, which Ogloblin has placed in the genus *Haplosomoides*.

Genus KHASIA Jacoby

Khasia Jacoby, 1899, Entomologist 32: 83 (type: *Khasia kraatzi* Jac.; S. India).

Head nearly as broad as prothorax; prothorax narrowed posteriorly; elytron short, narrowed or oblique apically; hind wing lacking.

The following do not fit perfectly in this

genus, and in some ways are closer to *Shaira* Maulik.

KEY TO FIJIAN SPECIES OF *Khasia*

1. Elytron distinctly rounded apically, somewhat smooth 2
   Elytron obliquely truncate apically, rugose 3

2(1). Prothorax with anterior angle forming a right angle; pronotum distinctly punctured; elytron carinate on humerus, sinuate at side, punctured basally . . . . **nigra**
   Prothorax with anterior angle obtuse; pronotum feebly punctured; elytron smooth on humerus, evenly rounded at side, almost impunctate . . . . . **nitida**

3(1). Pronotum almost entirely rugose-punctate . . . . **r. rugosa**
   Pronotum with a transverse central area raised and almost impunctate . . . . **r. callosa**

96. Khasia nigra Bryant

Khasia nigra Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 598 (Nausori; type in Brit. Mus.).

Black, shiny, slightly metallic, except for antennal base, femora, coxae, metasternum, and last abdominal sternite, which are fulvous. *Head* broad, rugose; *antenna* reaching elytral apex; scape long, broadening to apex, stouter than remainder; third longer than second; *prothorax* about as broad as long, very rugose, side constricted towards base; *elytron* widened towards apex, slightly rugose, basal half more so than apical, but much smoother than prothorax, longitudinally deeply impressed from shoulder for half length of elytron; side costate from humerus to just before apex; apex rounded; first four abdominal sternites feebly punctured. Length 3.5 mm.

VITI LEVU: Nausori (type locality). Tholo-i-suva (Colo-i-suva), June 1924, Bryan, July 1938, Zimmerman; Apr. 1951, Krauss; Naivithula, Tailevu, Sept. 1937, Valentine; Lami, Mar. 1951, Krauss; 20 specimens.

OVALAU: Andubangda and Draiba trail, July 1938, Zimmerman; two specimens.

97. *Khasia nitida* Bryant, n. sp.
Fig. 38

Shining brown, head and prothorax impunctate, elytron very feebly punctate-striate; four segments of abdomen exposed, nitid and impunctate; antenna and legs pale brown.

Head pale brown, nitid, transversely impressed between eyes, with a median longitudinal impression on basal half impunctate. *Antenna* extending well beyond base of elytron; first segment more dilated and longer than second; third slightly longer than second; third to eleventh all about equal, pale brown, terminal segments slightly pubescent. *Prothorax* pale brown, nitid, impunctate, slightly transverse, widest about middle, slightly contracted in front and more so at base, slightly broader than head; base as

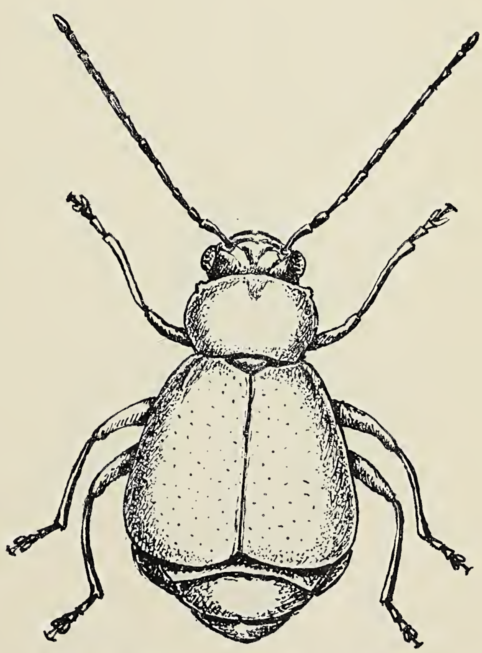

FIG. 38. *Khasia nitida* Bryant, n. sp., type.

broad as elytra at bases; basal margin slightly contracted in middle. *Scutellum* transverse, pale brown, nitid. *Elytron* pale brown with a broad longitudinal fuscous patch, gradually broadening to the rounded apex, very finely and not closely punctured. *Abdomen* exposed in both sexes, more so in the female. *Legs* and underside pale brown. Length 3.5–5 mm.

VITI LEVU: Holotype (BISHOP 2448), Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman. Eight paratypes (BISHOP, BM): Navai Mill, Nandarivatu, Oct. 13, Valentine; Navai-Nasonga trail, 1000 m., Sept. 12, 1938, Zimmerman; Mt. Korombamba, Aug. 1, 1938, Zimmerman; Lami, Mar. 1951, Krauss.

Differs from *K. nigra* Bryant in color, and in not being rugosely punctured.

98. *Khasia rugosa rugosa* Bryant, n. sp.

Fig. 39

Dull brown; head black, prothorax and elytron with side margins broadly black, in some extending to suture; entirely rugosely punctured; legs fulvous with apical third black.

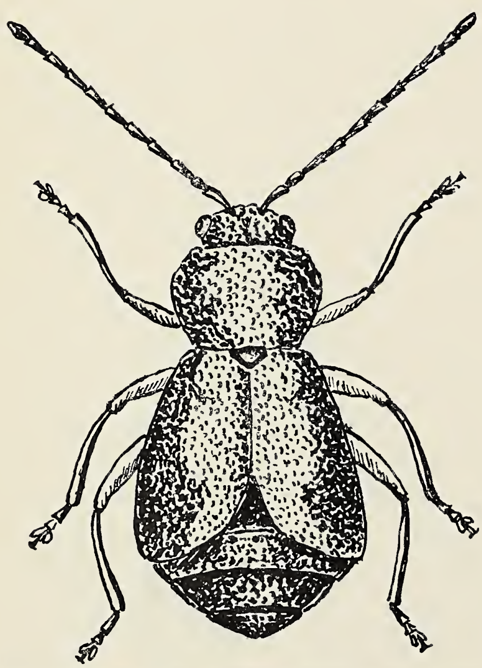

FIG. 39. *Khasia rugosa rugosa* Bryant, n. sp., type.

Head black, very rugosely punctured; *antenna* extending slightly beyond base of elytron, fulvous with apical segments tinged with fuscous; first segment longest, about twice as long as second. *Prothorax* dull brown with side margin broadly black; slightly transverse, widest just before middle, contracted to base, very strongly and rugosely punctured. *Scutellum* dull brown, impunctate. *Elytron* dull brown with side margin broadly black, in some extending to suture, rugosely punctured; punctures close and irregular; about as wide as base of prothorax, and gradually broadening to apex, somewhat truncate at apex and contracted upwards to suture, exposing two rugosely punctured abdominal segments. *Legs* fulvous with apical third of each tibia black. *Underside* with ventral segments of abdomen not so rugosely punctured.

VITI LEVU: Holotype (BISHOP 2449), Nandarivatu, Sept. 11, 1938, 800 m., Zimmerman, eight specimens; Tholo-i-suva, 175 m., July 21, 1938, Zimmerman, five specimens; Mt. Korombamba, 400 m., Aug. 1, 1938, Zimmerman, two specimens.

OVALAU: Thawathi, July 16, 1938, Zimmerman.

Easily distinguished from the other two species from Fiji by its very rugose appearance.

99. *Khasia rugosa callosa* Gressitt, n. subsp.

MALE: Black; antenna partly brownish in basal third; central portion of pronotum, from apex to base, testaceous; scutellum and base of elytron testaceous; thoracic sterna, coxae, and femora and tibiae (except apices of both) testaceous.

Head short, deeply punctured. *Antenna* reaching beyond middle of elytron; scape nearly as long as next two combined; fourth longer than any of succeeding. *Prothorax* broader than head, subhexagonal, widest at middle; disc with a broad, nearly impunctate area across central portion, the area partly divided into three portions; remainder densely rugose-punctate. *Scutellum* swollen. *Elytron*

less than twice as long as broad, obliquely truncate apically, densely rugose-punctate. Length 2.5 mm.; breadth 1.6 mm.

VANUA LEVU: Holotype, male (BISHOP 2450), Nakawanga, center of island, at 70 m., Oct. 8, 1955, Gressitt; paratopotype, male, Oct. 9, Gressitt.

Differs from the preceding in having a broad impunctate callus across the center of the pronotum, the elytron more shiny and more coarsely rugose, and the pale markings more restricted.

Genus CEROPHYSA Chevrolat

Cerophysa Chevrolat, 1837, in Dejean, Cat. Col. ed. 2: 379; ed. 3: 403; 1843, IN d'Orbigny, Dict. Univ. Hist. Nat. 3: 339 (type: *Galleruca nodicornis* Wiedem.; Java); Chapuis, 1875, Gen. Col. 11: 181.

Ozomena Chevrolat, 1845, Dict. Univ. Hist. Nat. 4: 5.

Head large, almost as broad as prothorax; antenna long, cylindrical, with ninth segment greatly enlarged in male; prothorax trapeziform, broader distally, transversely grooved; elytron finely and irregularly punctured.

This is an Oriental genus.

100. **Cerophysa vitiensis** Bryant

Cerophysa vitiensis Bryant, 1941, Ann. and Mag. Nat. Hist. Ser. 11, 8: 103, fig. 2 (Tamavua; type in Brit. Mus.).

Head, thorax and abdomen ochraceous, paler beneath; elytron black; antenna reddish brown, nearly black on ninth segment; legs ochraceous to pale brown. *Head* smooth and shiny above; *antenna* with second segment short, and ninth in male very broad, obliquely concave subapically; *prothorax* smooth, shiny, nearly impunctate; *elytron* with puncturation fine, but somewhat variable. Length 7–8 mm.; breadth 3.2–4 mm.

VITI LEVU: Korovou, Tailevu, Aug. 1937, Valentine; ridge west of Vatuthere, 800 m., Sept., and Tholo-i-suva, July 1938, Zimmerman.

VANUA LEVU: Nakawanga, 80 m., on *Gironniera*, Oct. 1955, Gressitt.

HOST: *Gironniera celtidifolia* Gaud.

Tribe MONOLEPTINI

Genus MONOLEPTA Erichson

Monolepta Er., 1843, Arch. f. Naturgesch. 9(1): 265 (type: *M. pauperata* Er.; Africa).

Subgenus METRIOIDEA Fairmaire

Metrioidea Fairm., 1882, Soc. Ent. de France, Ann. 50: 489 (type: *M. signatipennis* Fairm.; Fiji).

It is not certain that *Metrioidea* should be a subgenus of *Monolepta*. Yet all the species below seem to be structurally very closely related, and to differ from typical species of *Monolepta* in very minor respects, other than having the tibial spines minute. In addition to the type species, three species from the Malay subregion and Ceylon have previously been assigned to *Metrioidea*.

KEY TO FIJIAN SPECIES OF *Metrioidea*

1. Length of body over 2.8 mm.; dorsum pale with generally some vague oblique or irregular dark streaks **2**
   Length of body less than 2.7 mm.; dorsum black to brown, sometimes with pale spots, but without dark streaks **4**

2(1). Pronotum generally pale and without distinct dark markings; elytron rarely with distinct dark markings; length less than 3.4 mm. **3**
   Pronotum with a pair of longitudinal pitchy stripes on center, and generally other dark markings; elytron with two incomplete dark bands; length 3.5–5 mm. . . . . **s. signatipennis**

3(2). Ochraceous, with generally a few vague dark markings; length 2.6–3.4 mm. . . . . **s. lauana**
   Testaceous, almost entirely pale; length 2.4–3.2 mm. . . . . **s. kandavuna**

4(1). Dorsum black to pitchy brown, rarely with one or two pale areas on elytron; pronotum distinctly punctured; main islands 5

Dorsum uniformly castaneous brown, rarely a little paler or darker; pronotum generally feebly punctured or nearly impunctate; in Moala......... **moala**

5(4). Dorsum entirely black, or black with one or two pale areas on elytron; pronotum sparsely punctured ... **vitiensis**

Dorsum pitchy red-brown; pronotum rather closely punctured. **zimmermani**

101. *Monolepta (Metrioidea) signatipennis* (Fairmaire), n. comb.

Metrioidea signatipennis Fairm., 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 489 (Viti, Ovalau; type in Paris Mus.).

Pale brown: head darker on median line; pronotum with a pair of short longitudinal lines, or a "V," on center and more or less dark at side; elytron partly dark on suture and with two broad, incomplete dark bands, one just anterior to middle, other near apex, and a lesser mark behind humerus; metathorax somewhat dark. *Head* a little narrower than prothorax; eye very large, feebly emarginate; *antenna* slender, two-thirds as long as body, with scape longer than next two segments combined, and fourth nearly as long as scape; *prothorax* a little broader than long, slightly rounded at side, truncate anteriorly, strongly rounded basally, with disc even and feebly punctured; *elytron* finely and irregularly punctured, rounded apically. Length 3.5–5 mm.; breadth 2.3–2.6 mm.

VITI LEVU: Mt. Victoria and Nandarivatu, Sept. 1938, Zimmerman; Mt. Korombamba, Aug. 1938, Zimmerman; Belt road, 25 km. west of Suva, July 1938, Zimmerman; ridge west of Vatuthere, Sept. 1938, Kondo.

OVALAU: Draiba trail, Andubangda, and near Vuma, July 1938, Zimmerman.

Forty specimens.

102. *Monolepta (Metrioidea) signatipennis lauana* Gressitt, n. subsp.

Testaceous, somewhat more ochraceous above, with slightly darkened side of pronotum, and three feeble, incomplete, elytral bands.

Head with frons punctured at side and occiput quite smooth. *Antenna* three-fourths as long as body, with second and third segments subequal. *Prothorax* a little broader than long, rounded-obtuse at side, widest one-third from apex; disc finely punctured, in part impunctate. *Elytron* finely punctured, distinctly broadened preapically. Length 3.3 mm.; breadth 2 mm.

PARATYPES: Length 2.6–3.4 mm.; breadth 1.5–2.1 mm.

LAU: Holotype (BISHOP 2451) Bavatu, Vanua Mbalavu I., N. Lau Group, Aug. 16, 1938, Kondo. Fifteen paratypes (BISHOP, BM, US): Buthalevu, Vanua Mbalavu, 75 m., Aug. 10, 1938, Zimmerman; Mvana, Vanua Mbalavu, at seashore, Aug. 9, 1938, Zimmerman; Loma Loma, Vanua Mbalavu, Aug. 5, 1938, Zimmerman; Mbavatu, Vanua Mbalavu, Aug. 16, 1938, Zimmerman; Thikombia I., Sept. 26, 1924, Bryan; Navutu-i-loma, Aug. 10, 1924, Bryan; Yuvutha, Yangasa Cluster, Aug. 11, 1924, Bryan; 2 km. south of Narona, Mango I., Aug. 14, 1938, Zimmerman.

Differs from the typical form in being distinctly smaller, with feebler markings, and in having the side of the prothorax more obtuse.

103. *Monolepta (Metrioidea) signatipennis kandavuna* Gressitt, n. subsp.

Pale ochraceous, still paler on abdomen and hind femur, slightly darker on parts of hind thorax, median line of vertex and occiput, and side of pronotum.

Head nearly as broad as prothorax, smooth. *Prothorax* rounded-obtuse at side, broadest one-fourth from apex, feebly and irregularly punctured. *Elytron* finely punctured. Length 3.15 mm.; breadth 1.65 mm.

PARATYPES: Length 2.4–3.2 mm.; breadth 1.2–1.8 mm.

KANDAVU: Holotype (BISHOP 2452), Yawi, Apr. 28, 1941, Krauss. Eighteen paratypes (BISHOP, BM, US, CSIRO, CAS): two paratopotypes, same data; remainder Tiliva and Wai Salima, Apr. 30, 1941, Krauss.

Differs from the preceding subspecies in being still smaller, slightly paler, and almost without dark markings, thus differing from the typical form in being much smaller and almost one-colored.

104. *Monolepta (Metrioidea) moala* Gressitt, n. sp.

MALE: Reddish castaneous, paler on front of head; antenna and legs testaceous. Body subglabrous above, with a few fine pale hairs on elytral border; antenna, legs, and ventral surfaces with short sparse oblique pale hairs.

Head a little narrower than prothorax, about as broad as long, impunctate, with a pair of transverse swellings on vertex, smooth on occiput. *Antenna* three-fourths as long as body, slightly flattened beyond fifth segment; scape slightly longer than, and fourth subequal to, second and third segments combined; following subequal. *Prothorax* nearly as long as broad, obtusely rounded at side, broadest one-fourth from apex, broader at apex than at base, truncate anteriorly and convex basally, in outline; disc even, smooth, feebly punctured. *Scutellum* triangular. *Elytron* broadest in apical third, singly rounded apically; disc finely, irregularly, and not very closely punctured. Length 2.75 mm.; breadth 0.93 mm.

FEMALE: Body broader, a little more heavily punctured. Length 2.45 mm.; breadth 1.4 mm.

PARATYPES: Length 1.6–2.5 mm.; breadth 0.9–1.4 mm.

CENTRAL FIJI: Holotype, male (BISHOP 2453), Matuku, Moala Group, July 6, 1924, Bryan; allotopotype (BISHOP), July 4. Thirty-seven paratopotypes (BISHOP, BM, US, CSIRO, CAS): July 4–6, 1924, Bryan.

Differs from *M. signatipennis* (Fairm.) in being smaller, more convex, darker and more uniformly colored.

105. *Monolepta (Metrioidea) zimmermani* Bryant, new name

Monolepta modesta Bryant (nec Blackburn), 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 599 (Lautoka; type in Brit. Mus.).

Black to pitchy brown, nitid; prothorax with greenish reflections; antenna, tibiae, and tarsi flavous. *Head* smooth; *antenna* with fourth segment about equal to scape, fifth a very little shorter than fourth; *prothorax* nitid, rather strongly punctured, narrower than elytral base, slightly broader than long, very little contracted at base, from middle slightly converging to apex; *elytron* strongly and rather closely punctured, punctures about as strong as those on prothorax, side gradually widening from base to beyond middle and there rounded to apex; *abdominal sterna* feebly punctured and slightly pubescent.

FEMALE: With second and third antennal segments slightly longer. Length 2.4–2.7 mm.; breadth 1.15–1.3 mm.

VITI LEVU: Lautoka (type loc.). Tholo-i-suva (Colo-i-suva), June 1924, Bryan; Natabakula, near Singatoka, Apr. 1941, Krauss.

OVALAU: Wainiloka, Draiba trail, July 1938, Zimmerman; four specimens.

A specimen from Kalambu, near Suva, Apr. 1941, Krauss, does not agree in puncturation.

106. Monolepta (Metrioides) vitiensis Bryant

Monolepta vitiensis Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 599 (Labasa; type in Brit. Mus.).

Blackish brown, nitid; antenna, frons, legs, humeri, and venter testaceous. *Head* smooth, a transverse impression between eyes; *antenna* filiform, reaching beyond middle of elytron; scape long, slightly curved, longer than second and third segments combined, second and third subequal, second slightly more swollen than third, fourth equal to second and third combined; *prothorax* strongly punctured, much narrower than elytra, very little broader than long, side nearly straight;

elytron closely punctured, but less strongly so than on prothorax, slightly depressed behind shoulder, broadest behind middle, rounded at apex; *abdominal sternites* slightly pubescent; first hind tarsal segment longer than rest. Length 2.2–2.5 mm.; breadth 1–1.2 mm.

VANUA LEVU: Lambasa (type loc.). Nakawanga, 45 m., on *Inocarpus*, Oct. 1955, Gressitt; 15 specimens.

HOST: *Inocarpus fagiferus* (Parkinson) Fosberg.

This species is apparently variable in color. All of the ten females in the above series are entirely black above; two of the males are entirely black above; one male has only the humerus pale, as in the type series; and two males have two large pale spots on the elytron. This species was observed to jump.

Subfamily *ALTICINAE*

KEY TO FIJIAN GENERA OF ALTICINAE

1. Antenna of 11 segments 2
   Antenna of 10 segments . . **Psylliodes**

2(1). Anterior coxal cavity open behind . . . 3
   Anterior coxal cavity closed or nearly closed behind; pronotum with basal depressed area . . . . **Crepidodera**

3(2). Pronotum with a depression parallel to basal margin 4
   Pronotum without a depression parallel to basal margin 6

4(3). Elytral punctures in regular rows; body length less than 3 mm. 5
   Elytral punctures irregular; body length about 5 mm. . . . . **Altica**

5(4). Prothorax transverse, rounded at side . . . . **Manobia**
   Prothorax nearly as long as broad, subtrapeziform, broadest apically . . . . **Alema**

6(3). Elytral punctures irregular or obsolete; body length generally less than 2 mm. 7
   Elytral punctures generally in regular rows; body length 3 mm. or more. **Febra**

7(6). Posterior tibia not depressed at apex, which is rounded and furnished with a small spinule placed in the middle of the terminal border 8
   Posterior tibia depressed at apex, which is divided into two very short lobes, each usually ending in a short spinule . . . . **Aphthona**

8(7). Second antennal segment more slender than scape; prosternal intercoxal process narrow . . . . **Phyllotreta**
   Second antennal segment as stout as scape; prosternal intercoxal process broad, concave . . . . **Nesohaltica**

Genus PHYLLOTRETA Stephens

Phyllotreta Stephens, 1839, Man. Brit. Col.: 291 (type: *Chrysomela nemorum* L.; Europe); Maulik, 1926, Fauna of India, Col. Chrys. Halt.: 377.

Head as broad as prothorax; eye small; interantennal carina short; antenna reaching middle of elytron; scape clavate, second and third segments small; prothorax transverse, slightly rounded at side; elytron as a rule confusedly punctate; prosternum very narrow; fore coxal cavity open; hind tibia not channelled and with a small apical spine; first hind tarsal segment equal in length to remaining combined.

107. **Phyllotreta blackburni** Bryant

Phyllotreta blackburni Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 596 (Nadar, Cuvu; type in Brit. Mus.).

Bronzy black; five basal segments of antenna and bases of tibiae testaceous; elytron with a yellow discal stripe, bent in at base and dilated at apex. Dorsum closely and finely punctured.

VITI LEVU: Nandar; Thuvu.

New Hebrides.

Genus APHTHONA Chevrolat

Aphthona Chevr., 1842, IN d'Orbigny, Dict. Univ. Hist. Nat. 2: 5; Maulik, 1926, Fauna of India, Col. Chrys. Halt.: 366 (type *Altica cyparissiae* Koch; Europe).

Head with vertex impunctate, often tuberculate; antenna reaching middle of elytron; scape long and clavate; eye oval, prominent; prothorax transverse, without a basal transverse depression; elytron oblong, rounded at apex, finely and confusedly punctate; anterior coxal cavity open; hind tibia dilated from base to apex, outer side flat with edges set with fine bristles, and outer edge sometimes with spinules, apex often ending in a spine on outer side; first hind tarsal segment distinctly less than half as long as tibia.

KEY TO FIJIAN SPECIES OF *Aphthona*

1. Dorsum black or blackish, rather distinctly punctured 2
   Dorsum reddish testaceous, nearly impunctate . . . . **veitchi**

2(1). Pronotum rather sparsely punctured . 3
   Pronotum rather closely punctured; dorsum greenish black, somewhat purplish on posterior portion of elytron; appendages dull reddish to slightly pitchy; length 2.9 mm. . . . . **lamia**

3(2). Pronotum strongly punctured, with a mid-basal longitudinal impression; hind femora black; length 2 mm. . . . . **greenwoodi**
   Pronotum finely punctured without a longitudinal impression; hind femora reddish; length 1.6 mm. . . . . . **senetiki**

108. **Aphthona veitchi** Bryant

Aphthona veitchi Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 595 (Cuvu; Lautoka; type in Brit. Mus.). Greenwood, 1940, Linn. Soc. N. S. Wales, Proc. 65: 215.

Flavous, shiny; labrum, apical antennal segments and hind femur darker. *Head* smooth, shiny; frons carinate between antennal insertions; *antenna* reaching middle of elytron; scape equal in length to next two segments combined; fifth slightly longer than either fourth or sixth; *prothorax* smooth, shiny, a little broader than long, slightly rounded at side; *elytron* slightly dilated beyond middle, very feebly punctured; first hind tarsal segment equal to next two combined. Length 2 mm.

VITI LEVU: Thuvu; Lautoka.

OVALAU: Andubangda, Aug. 1938, Zimmerman; questionably this species.

HOST: Adult feeds on leaves of *Euphorbia chamissonis* Boiss (after Greenwood).

109. **Aphthona greenwoodi** Bryant

Aphthona greenwoodi Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 595 (Loloti; type in Brit. Mus.).

Black, shiny; labrum, antenna, fore and middle legs and hind tibia fuscous. *Head* finely punctured; *antenna* with first two segments about equal and thicker than following; *prothorax* transverse, with anterior angles oblique, strongly but sparsely punctured, a feeble longitudinal impression in middle at base; *elytron* strongly and irregularly punctured. Length 2 mm.

VITI LEVU: Loloti.

110. *Aphthona lamia* Gressitt, n. sp.

MALE: Metallic greenish black above, in certain lights dull purplish on inner half of posterior two-thirds of elytron, and particularly so on ectoapical portion of elytron; front of head, ventral surfaces, and appendages largely testaceous; hind leg more reddish ochraceous.

Body broad. *Head* finely punctured in front, nearly impunctate on occiput. *Antenna* two-thirds as long as body, slender; scape a little longer, and a little stouter, than second segment; third as long as second, but more slender; fourth slightly longer than third, slightly shorter than fifth. *Prothorax* less than

two-thirds as long as broad, strongly convex, deeply and rather closely punctured, all four corners prominent. *Scutellum* rounded-triangular, nearly smooth. *Elytron* deeply, somewhat closely, and irregularly punctured, the punctures slightly finer apically; suddenly narrowed, and declivitous, apically. *Ventral surfaces* in part finely punctured. *Hind femur* nearly reaching to abdominal apex; hind tibia shallowly concave behind; first hind tarsal segment nearly as long as remainder combined. Length 1.8 mm.; breadth 1.2 mm.

FEMALE: Antenna one-half as long as body. Length 2.9 mm.; breadth 1.6 mm.

VITI LEVU: Holotype, female (BISHOP 2455), Lami Quarry, near Suva, May 1951, Krauss; allotype, female, Tholo-i-suva, Jan. 1955, Krauss; 9 paratopotypes, May 1951, Krauss; one paratype, Navai, Sept. 1950, Krauss; one, Tholo-i-suva, Apr. 1951, Krauss.

Differs from *A. greenwoodi* Bryant in being much larger, greenish instead of black, with the pronotum closely punctured, and the hind femur reddish instead of black.

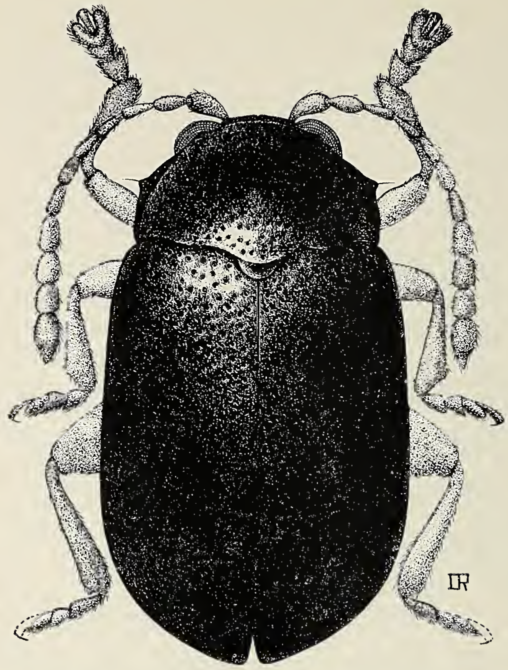

FIG. 40. *Aphthona senetiki* Gressitt, n. sp., type.

111. *Aphthona senetiki* Gressitt, n. sp.
Fig. 40

FEMALE: Body shiny black to pitchy black above, dark reddish pitchy beneath; slightly pitchy on elytral disc; head pitchy anteriorly; eye pinkish silvery; antenna and fore and middle legs testaceous, in part tinged with pitchy; hind legs reddish castaneous.

Body narrow. *Head* largely impunctate, with a subtransverse groove behind a pair of swellings immediately behind antennal insertions. *Antenna* two-thirds as long as body, distinctly thickened distally; scape moderately stout, a little longer than second segment; third longer than second, and more slender; fourth to tenth subequal to third; last longer and much stouter. *Prothorax* three-fifths as long as broad, rounded at side, corners not very prominent, finely and sparsely punctured. *Scutellum* short, rounded-triangular. *Elytron* nearly three times as long as head and prothorax combined, distinctly, and irregularly punctured throughout, the punctures mostly about as large as interspaces. First hind tarsal segment nearly as long as remaining combined. Length 1.6 mm.; breadth 0.95 mm.

VANUA LEVU: Holotype, female (BISHOP 2456), between Navakuru and Nakawanga, 400 m., Oct. 7, 1955, Gressitt.

Differs from *A. greenwoodi* Bryant in being smaller, more parallel-sided, with the hind femur reddish, the pronotum much more finely punctured, and without a longitudinal impression, and with the elytron a little more finely punctured. Named for Senetiki, government agricultural assistant, who accompanied me on the walk across Vanua Levu.

Genus ALTICA Müller

Altica Müller, 1764, Fauna Ins. Fridrichsdal.: XIV; Fabricius, 1775, System. Ent. :112.

Haltica Koch, 1803, Ent. Hefte 2: 5 (type: *Chrysomela oleracea* L.; Europe); Maulik, 1926, Fauna of India, Col. Chrys. Halt.: 418.

Head with frontal tubercles and a sharp frontal ridge; second and third antennal segments of equal thickness; third and fourth subequal in length; pronotum with deep transverse basal depression with a longitudinal groove at each end, elytron irregularly punctured; fore coxal cavity open.

112. Altica corusca Erichson

Haltica corusca Erichson, 1842, Arch. f. Naturgesch. Ser. 8, 1: 235; (Tasmania); Blackburn, 1896, Roy. Soc. S. Australia, Trans. 20: 73, 75.

Haltica gravida, Veitch and Greenwood, 1921, Linn. Soc. N. S. Wales, Proc. 46: 511.

Black, slightly tinged with purplish to bronzy. *Head* slightly shagreened, with a pair of feeble swellings between eyes; *antenna* with segments of equal thickness, and of equal length except for second which is half as long as others; prothorax micropunctulate, feebly grooved basally; *elytron* finely and irregularly punctured; *ventral surfaces* rather hairy. Length 4.2–5 mm.

LARVA: Dark brown to blackish; head blackish, paler at side; antenna and clypeus largely whitish; about 18 hairs on each side of head. Body with swollen areas dark brown and less sclerotized areas pale brown; pronotum somewhat generally sclerotized, with a strong basal transverse swelling, each side with seven bristles anteriorly and three basally; mesonotum and metanotum each with central, anterior, and posterior transverse swellings, each with a pair of bristles, a sublateral basal transverse swelling with two bristles, and a lateral swelling with three bristles, besides a small additional anterior spot on metanotum; first seven abdominal tergites each with anterior and posterior central transverse swelling with a pair of bristles, five sublateral tubercles each with one bristle, and a lateral swelling with two bristles. Length 8 mm. (Larva from Lami, Krauss.)

VITI LEVU: Nandarivatu, Navai Mill, Tholo-i-suva, Matawailevu, Zimmerman; Suva, Singatoka, Valentine; Matawailevu, St. John; Vunindawa, Lami, Ndeumba, Krauss; Nandi, Koronivia, Gressitt.

OVALAU: Thawathi, near Vuma, Wainiloka, Zimmerman, Bryan.

VANUA LEVU: Wailevu, Gressitt.

LAU: Lakemba I., Bryan.

KANDAVU: Vambea, Ono I., Krauss.

Tasmania, New Hebrides, Fiji. Four hundred specimens from Fiji.

HOST: *Jussiaea villosa* (*J. repens*), *J. suffruticosa* L., *Oryza sativa* L., on growing leaf tips of rice (Lever).

Genus CREPIDODERA Chevrolat

Crepidodera Chevrolat, 1844, IN d'Orbigny, Dict. Univ. Hist. Nat. 4: 441 (type: *Chrysomela nitidula* L.); Chapuis, 1875, Gen. Col. 11: 53.

Head deeply inserted in prothorax; antenna with terminal segments slightly thickened; pronotum with a deep transverse groove near base, the groove delimited at each end by a depression or short longitudinal groove; elytra seriate-punctate.

KEY TO FIJIAN SPECIES OF *Crepidodera*

1. Body largely pale 2
   Body largely black or metallic, at least on elytra 3

2(1). Body entirely pale; pronotum finely punctured; elytron heavily punctured . . . . **elongata**
   Distal antennal segments, suture, and side of elytron dark; pronotum impunctate; elytron feebly punctured . . . . **evansi**

3(1). Dorsum uniformly black 4
   Prothorax differently colored from elytra 5

4(3). Prothorax deeply grooved; body twice as long as broad; a distinct postbasal elytral swelling . . . . **fijiensis**

Prothorax shallowly grooved; body less than twice as long as broad; elytron even basally . . . . **rotunda**

5(3). Pronotum greenish black; elytron metallic purplish, with a heavily punctured depression behind postbasal swelling . . . . **kraussi**

Pronotum testaceous; elytron brownish black, with a moderately punctured depression behind postbasal swelling . . . . **oceanica**

113. *Crepidodera oceanica* Gressitt, n. sp.
Fig. 41*a*

FEMALE: Fore body testaceous; antenna slightly dull distally; elytron pitchy purplish brown, slightly paler posteriorly; metathorax, abdomen, and hind femur pitchy red-brown; hind tibia and tarsus testaceous. Subglabrous above, with a few pale hairs on apical margin of elytron; appendages with short pale hairs, and last abdominal segment with a few at side.

Head nearly as broad as long, strongly carinate medially on frons and vertex, nearly impunctate on occiput. *Antenna* fully two-thirds as long as body; scape distinctly longer than second segment, subequal to third; third longer than fourth and shorter than fifth; sixth to tenth subequal to third; last longer. *Prothorax* nearly three-fourths as wide as elytra at humeri, just over two-thirds as long as broad, about as broad at apex as at base, moderately rounded at side, straight on anterior margin and convex and sinuate basally; disc nearly impunctate, sinuately grooved subbasally. *Scutellum* triangular. *Elytron* three and one-half times as long as prothorax, slightly broadened behind humerus, narrowed apically; disc with ten rows of fairly regular rows of punctures continuing to behind middle, the punctures mostly smaller than interspaces, and also minute punctures in the interspaces. *Ventral surfaces* largely impunctate, with a few vague punctures, and some microreticulation, on abdomen. *Legs* with hind femur very stout, and hind tibia

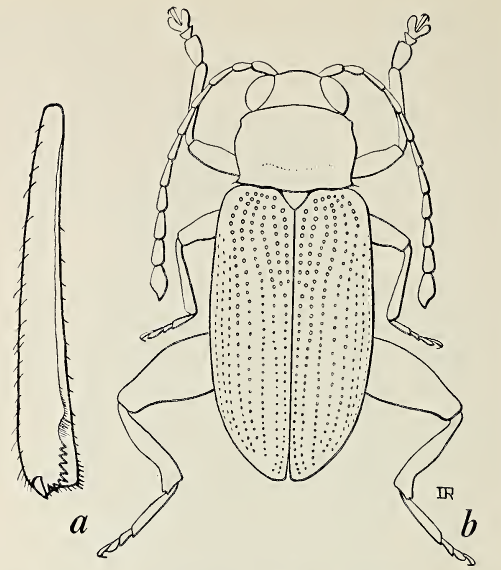

FIG. 41. *a*, *Crepidodera oceanica* Gressitt, n. sp., dorsolateral view of left hind tibia; *b*, *Crepidodera elongata* Gressitt, n. sp., type.

feebly arched, flat above, with several slender teeth on each upper margin at apex, besides a short stout tooth on outer side at end; hind tarsus with first segment one-half again as long as remainder combined. Length 3.25 mm.; breadth 1.4 mm.

MALE: Elytron less attenuated apically. Length 2.5 mm.; breadth 1.25 mm.

PARATYPES: Length 2.4–3.2 mm.; breadth 1.1–1.4 mm.

VITI LEVU: Holotype, female (BISHOP 2457), Lami Quarry, near Suva, May 1951, Krauss; allotopotype, male (BISHOP), same data. Sixty-six paratopotypes (BISHOP, BM, US, CSIRO, CAS), May 1951, Jan. and Mar. 1955, Krauss.

Differs from *C. dimidiata* Baly in having the scutellum "V"-shaped instead of "U"-shaped, the minute punctures on elytral interspaces more distinct, the hind tibia narrower and straighter, the first hind tarsal segment longer, instead of shorter, than remaining segments combined, and the hind tibia and tarsus pale instead of dark. I am indebted to Mr. Zimmerman for the comparative notes. Bryant (1936: 251) referred to *C. dimidiata* as occur-

ring in Fiji, but probably this species was involved. Some of the specimens are quite brown on the inner portion of the elytral disc. One specimen with longer, entirely blue, elytron probably represents another species.

114. *Crepidodera elongata* Gressitt, n. sp.
Fig. 41*b*

MALE: Testaceous, slightly more ochraceous on thoracic and abdominal sterna and on side and preapical portion of elytron.

Body narrow; tarsi long. *Head* long; frons short and tuberculate; upper surface smooth, nearly impunctate. *Antenna* three-fourths as long as body; scape nearly one-half again as long as second segment, both stout; third nearly as long as scape, barely longer than fourth; fifth fully as long as scape, longer than each of sixth to tenth; last several thickened; last thicker than scape. *Prothorax* slightly broader than long, subrectangular, slightly sinuate at side; disc minutely punctured, distinctly grooved subbasally. *Scutellum* rounded triangular. *Elytron* long, subparallel, moderately swollen postbasally near suture, regularly and deeply seriate-punctate, the punctures mostly larger than interspaces, both longitudinally and transversely. *Ventral surfaces* sparsely or finely punctured. *Legs* long; fore and middle tarsus each with first segment as long as next two combined, fully as broad as third, and much larger than second; hind tarsus longer than its tibia, with first segment longer than following combined. Length 2.6 mm.; breadth 1.2 mm.

OVALAU: Holotype, male (BISHOP 2458), Andubandga, beating shrubs, at 500 m., Aug. 15, 1938, Zimmerman.

Differs from *C. evansi* Bryant in being entirely pale, in having the pronotum finely punctured, and the elytron heavily punctured and with the punctures extending to apex.

115. Crepidodera evansi Bryant

Crepidodera evansi Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 251 (Taveuni; type in Brit. Mus.).

Elongate-oval, nitid, fulvous, with distal antennal segments, suture, and sides of elytron, fuscous. *Head* impunctate; *antenna* with second segment about one-half as long as first; third and fourth subequal, each longer than second; fifth slightly longer than fourth or sixth. *Prothorax* impunctate, feebly rounded at side, anterior angles oblique, transverse sulcus not very deep, terminated at each end by a short longitudinal sulcus. *Elytron* about twice as long as head and prothorax together, feebly punctate-striate, the apical portion impunctate, feebly carinate at side, widest behind middle and rounded at apex. *Hind tibia* with apical third finely toothed. Length 3 mm.

TAVEUNI: Quilai, 250 m.

116. Crepidodera fijiensis Csiki

Crepidodera nigra Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 597 (Labasa; Lautoka; type in Brit. Mus.).

Crepidodera fijiensis Csiki, 1939, Coleopt. Cat. 166: 298 (new name for *nigra* Bryant, *nec* Schilsky).

Entirely black except for basal antennal segments, which are testaceous, and apical segments, tibiae, and tarsi, which are fuscous. *Head* sulcate between eyes, smooth on vertex; *antenna* reaching a little beyond middle of elytron, first two segments rather swollen, third to sixth more slender, last five thicker; *prothorax* smooth, slightly transverse, with a strong basal sulcus which is terminated at each end by a short longitudinal sulcus; *elytron* twice as long as prothorax, with basal half strongly but irregularly punctured, forming irregular striae which behind middle become feeble and at the apex almost smooth. Length 2.25 mm.

VITI LEVU: Mt. Evans; Lautoka; Lami Quarry, near Suva, May 1951, Krauss; 25 specimens.

VANUA LEVU: Lambasa (type locality).

117. *Crepidodera kraussi* Gressitt, n. sp.

MALE: Reddish pitchy; antenna largely testaceous, pitchy on most of scape; pro-

notum metallic greenish black, bordered with pitchy; elytron metallic purplish.

Head carinate medially and grooved on each side between antennal insertions, the grooves continuous with grooves bordering eyes; occiput smooth and impunctate. *Antenna* slender, fully two-thirds as long as body; first two segments not very stout, scape half again as long as second; third to sixth slender, increasing slightly in length; last longest. *Prothorax* transverse, suboblong, slightly convex on lateral and basal margins; disc strongly convex, impunctate, deeply grooved subbasally. *Scutellum* rounded-triangular. *Elytron* long, somewhat gradually narrowed posteriorly, strongly swollen on disc behind base, unevenly punctured: punctures in rows, but postbasal swelling and posterior half of disc practically impunctate, and punctures strongest in depression behind postbasal swelling. *Ventral surfaces* finely and irregularly punctured. *Middle tarsus* with first segment nearly as long as next two combined, and narrower than third; hind tibia shallowly, and somewhat obliquely grooved posteriorly. Length 2.4 mm.; breadth 1.15 mm.

VITI LEVU: Holotype, male (BISHOP 2459), Lami Quarry, near Suva, May 1951, Krauss; allotopotype, female, and two male paratopotypes, same data.

Differs from *C. caeruleoviolacea* Bryant, of New Hebrides, in being smaller, in having the prothorax greenish, the elytron less bluish and much less even and less regularly punctured. Named in honour of N. L. H. Krauss, of Honolulu, the collector of a number of species described in this work.

118. *Crepidodera rotunda* Gressitt, n. sp.

FEMALE: Shiny black above, dark pitchy reddish beneath and on hind femur; antenna testaceous; legs reddish.

Head stout, smooth and shiny above. *Antenna* slightly over half as long as body, fairly slender; first two segments moderately thickened, scape a little longer than second; third about as long as second; fourth and fifth successively longer; sixth a little shorter than fifth and seventh; remainder subequal. *Prothorax* about three-fifths as long as broad, slightly convex in outline of each border; front corner oblique; disc subevenly convex, smooth, minutely punctulate, feebly grooved subbasally. *Scutellum* triangular, finely punctured. *Elytron* broad, even, without a postbasal swelling or depression; moderately, and regularly, punctured on basal three-fourths, the punctures smaller than interspaces, and with minute punctulation on general surface. *Abdomen* finely punctured. Fore and middle tarsus with first three segments subequal; hind tibia with posterior face flat or shallowly depressed for entire length, finely toothed on outer edge. Length 2.25 mm.; breadth 1.3 mm.

VITI LEVU: Holotype, female (BISHOP 2460), Lami Quarry, near Suva, May 1951, Krauss; paratopotype, female (elytra lacking), same data.

Differs from *C. fijiensis* Csiki (*nigra* Bryant), in being much broader, less than twice as long as broad, with the pronotum very shallowly grooved subbasally, and the elytron even, without a postbasal swelling followed by a depression.

Genus PSYLLIODES Latreille

Psylliodes Latreille, 1829, IN Cuvier, Regne Anim. 2 ed., 5: 154; Maulik, 1926, Fauna of India, Chrysom. and Haltic.: 124 (type: *Chrysomela chrysocephala* L.).

Head smooth or carinate medially; antenna 10-segmented; prothorax transverse, feebly rounded at side; elytron broader basally than prothorax, as a rule regularly punctate-striate; scutellar rows of punctures generally long; hind tibia broadened distally and channelled above, the channel bordered with spinules, with tarsal insertion considerably before apex; first hind tarsal segment long and slender; claws simple.

KEY TO FIJIAN SPECIES OF *Psylliodes*

1. Dorsum purplish black; antenna fulvous; elytron irregularly punctured; apical process of hind tibia tridentate. . . **simmondsi**

   Dorsum greenish; antenna pitchy with basal segments testaceous; elytron striate-punctate; apical process of hind tibia bidentate. **vitiensis**

119. **Psylliodes simmondsi** Bryant

Psylliodes simmondsi Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 252 (Tamavua; type in Brit. Mus.).

Purplish black above; antenna, legs and venter fulvous. *Head* with basal half black, impunctate; *antenna* with five terminal segments tinged with fuscous; *prothorax* feebly and not closely punctured; *scutellum* impunctate; *elytron* rounded apically, irregularly punctured, the punctures stronger and closer than on pronotum; *hind femur* tinged with fuscous; apical process of hind tibia short and tridentate. Length 2.5 mm.

VITI LEVU: Tamavua (type locality).

120. **Psylliodes vitiensis** Bryant

Psylliodes vitiensis Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 597 (Cuvu, Lautoka; type in Brit. Mus.).

Greenish above; antenna pitchy with basal segments testaceous; venter piceous; legs testaceous. *Head* finely punctured; *antenna* with distal segments gradually increasing in length to apex; *prothorax* transverse, broadest at base, obtuse at anterior angle, evenly punctured, the punctures stronger than on head; *elytron* feebly striate, but strongly punctate, the punctures becoming feebler towards apex; *hind tibia* with apical process long, but shorter than first segment of hind tarsus, its apex bidentate; abdominal sternites finely punctured. Length 3 mm.

VITI LEVU: Thuvu; Lautoka.

Genus ALEMA Sharp

Alema Sharp, 1876, Ent. Monthly Mag. 13: 98 (type: *A. paradoxa* Sharp; New Zealand); Broun, 1880, Man. New Zealand Col. 1: 619.

KEY TO FIJIAN SPECIES OF *Alema*

1. Black, with second to sixth antennal segments fulvous; elytron strongly punctate-striate and costate. . . . . **leveri**

   Black, with antenna, clypeus, palpi and legs fulvous; elytron finely punctate-striate, with interstices slightly elevated. . . . . **nigra**

121. **Alema leveri** Bryant

Alema leveri Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 428 (Taveuni; type in Brit. Mus.).

Shiny black, second to sixth antennal segments fulvous. *Head* impunctate; eye prominent; *antenna* slender, reaching middle of elytron; scape equal to next two combined; second shorter than third. *Prothorax* subquadrate, sides feebly margined and contracted towards base; a transverse depression near base containing a few strong punctures; scutellum impunctate. *Elytron* tapering apically, strongly punctate-striate and costate. Length 2 mm.

TAVEUNI: Crater Lake (type locality).

122. **Alema nigra** Bryant

Alema nigra Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 252 (Lautoka Mts.; type in Brit. Mus.).

Black, with antenna, clypeus, palpi and legs fulvous. *Head* with basal portion shiny and impunctate, interocular space elevated; *antenna* with pedicel rather shorter than scape, remainder elongate and slender, subequal. *Prothorax* subquadrate, feebly punctured, slightly depressed near base; scutellum impunctate. *Elytron* finely punctate-striate with

interstices slightly elevated, tapering sharply to apex; exposing extremity of pygidium. *Metasternum* impunctate; first abdominal sternite about as long as next three together, last feebly punctured. Length 2 mm.

VITI LEVU: Lautoka Mts. (type locality). One, Nandarivatu, 1100 m., Sept. 1938, Zimmerman, is questionably referred to this species.

Genus MANOBIA Jacoby

Manobia Jacoby, 1885, Mus. Civ. Genova, Ann. 22: 73 (type: *Manobia nigripennis* Jac.; Sumatra).

Ovate-subquadrate, convex; antenna nearly as long as body; terminal segments slightly thickened; prothorax with a depression near basal margin; scutellum broadly ovate; elytron deeply depressed behind the raised base, coarsely punctate-striate; hind tibia with small apical spine; first hind tarsal segment equal to next two united; claws appendiculate.

KEY TO FIJIAN SPECIES OF *Manobia*

1. Dorsum reddish brown to blackish; scape less than twice as long as second antennal segment 2

   Dorsum dark metallic green; scape twice as long as second segment. . . . . **metallica**

2(1). Basal portion of pronotum distinctly and sinuately grooved, or feebly depressed and strongly punctured 3

   Basal portion of pronotum with a distinct, smooth, and nearly impunctate, gradual depression . . . . **levicollis**

3(2). Dorsum pitchy black; base of pronotum distinctly and sinuately grooved; second antennal segment distinctly larger than third . . . . . . **producticollis**

   Dorsum reddish brown; base of pronotum feebly depressed; second antennal segment hardly larger than third . . . . **obtusicollis**

123. Manobia metallica Bryant

Manobia metallica Bryant, 1945, Ann. and Mag. Nat. Hist. Ser. 11, 12: 427 (Tomaniivi; type in Brit. Mus.).

Dark metallic green; antenna and legs flavous. *Head* shiny, impuncate; *antenna* reaching middle of elytron, scape twice as long as second segment; *prothorax* shiny, finely punctured, more strongly so basally; *elytron* with interpunctural rows near side slightly costate. Length 2 mm.

VITI LEVU: Mt. Victoria (Tomaniivi): 900 m.; type locality.

124. *Manobia levicollis* Gressitt, n. sp.
Fig. 42

Dark reddish brown; tarsi testaceous; antenna pale brown with third to fifth segments testaceous and scape dark brown.

Head carinate medially on frons, finely grooved medially just behind antennal insertions; smooth and impunctate on occiput. *Antenna* more than one-half as long as body, distinctly thickened in last five segments; scape a little longer than second segment; third smaller, subequal to fourth; fifth longer, subequal to sixth; seventh and following each longer, and thicker, than sixth. *Prothorax* slightly broader than long, much longer in middle than at side, anterior and posterior angles oblique; basal margin sinuate, strongly convex at middle; disc smooth and shiny, very finely and sparsely punctured, gradually and broadly depressed near base. *Scutellum* rounded-truncate apically. *Elytron* swollen near base, depressed behind swelling, seriate-punctate, the punctures larger in depression and becoming quite fine in posterior quarter. *Abdomen* finely punctured. *Hind femur* small; hind tibia slender, feebly grooved behind; first hind tarsal segment shorter than remaining combined. Length 1.65 mm.; breadth 0.8 mm.

VITI LEVU: Holotype, male (BISHOP 2461), Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman.

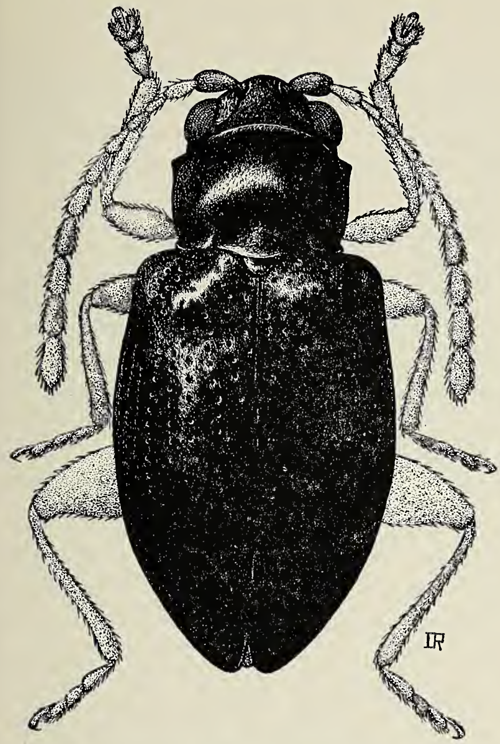

FIG. 42. *Manobia levicollis* Gressitt, n. sp., type.

Differs from *M. metallica* Bryant in being smaller, dark reddish instead of metallic green, with the scape much less than twice as long as second antennal segment, and the pronotum finely punctured basally.

125. *Manobia obtusicollis* Gressitt, n. sp.

Reddish brown, slightly pitchy on sides of metasternum and abdomen; antenna and legs pale ochraceous.

Head with frons fairly large, smooth; occiput impunctate. *Antenna* not quite reaching to middle of elytron; scape one-half again as long as second segment; third nearly as long as scape, subequal in length to following, which gradually increase in thickness; last longer. *Prothorax* three-fourths as long as broad, slightly broadened from base to apex, feebly convex at side, distinctly obtuse basally; disc subevenly convex, finely punctured, slightly depressed and somewhat more strongly punctured near base. *Scutellum* small, nearly hidden by pronotum. *Elytron* broadest anterior to middle, considerably attenuated apically; disc strongly swollen near base, depressed behind swelling, deeply punctured in fairly regular rows, the punctures stronger in postbasal depression and becoming very fine apically, the interspaces distinctly raised, particularly at side. *Ventral surfaces* slightly punctured. *Hind femur* not very stout; first hind tarsal segment nearly as long as remaining combined. Length 2.3 mm.; breadth 1.15 mm.

VITI LEVU: Holotype (BISHOP 2462), Nandarivatu, 1100 m., Sept. 6, 1938, Zimmerman. Two additional specimens, one of nearly same data as type, and the other from Tholo-i-suva, June 28, 1924, Bryan, are only tentatively associated with this species.

Differs from *M. costata* Bryant, in being reddish instead of partly greenish, in having the antenna paler, and the pronotum less strongly punctured.

126. *Manobia producticollis* Gressitt, n. sp.

MALE: Dark pitchy black above, more reddish pitchy beneath and on appendages; second to fourth antennal segments more reddish than remainder.

Head fairly long, produced at mouth parts, smooth on occiput. *Antenna* barely more than one-half as long as body; first two, and last five, segments thicker than others; scape a little longer than second segment; third smaller than second; fourth a little longer than third, subequal to fifth and following in length. *Prothorax* two-thirds as long as broad, broadened from base to apex, with side fairly straight; basal margin sinuate, strongly rounded and produced at middle; disc strongly convex, finely punctured, with a sinuate, more strongly punctured, subbasal depression. *Scutellum* small, subrounded behind. *Elytron* broadest anterior to middle; disc with a distinct postbasal swelling followed by a depression, distinctly punctured throughout in regular rows, the punctures slightly larger in postbasal depression and slightly finer near

apex. *Ventral surfaces* finely punctured. *Hind femur* moderately stout; first hind tarsal segment about as long as remaining combined. Length 1.7 mm.; breadth 0.95 mm.

VITI LEVU: Holotype, male (BISHOP 2463), Lami Quarry, near Suva, May 1951, Krauss; allotopotype, female, same data; 13 paratopotypes, same data; one paratype, Navai, Mar. 1951, Krauss.

Differs from *M. costata* Bryant, of New Hebrides, in being darker, with the elytra blackish and not greenish, and the pronotum more evenly punctured. This species may possibly belong to *Alema*.

Genus NESOHALTICA Maulik

Nesohaltica Maulik, 1929, Insects of Samoa 4(3): 201 (type: *N. nigra* Maulik; Samoa).

Rounded oblong; head with vertex delimited from interocular space by a deep transverse groove; raised areas in interocular space weakly developed; antenna 11-segmented, with two basal and five apical segments thickened; eye entire; prothorax transverse, rounded at side, each corner with a seta; elytron irregularly punctate; fore coxal cavity open, prosternal process broad, concave, rough; hind tibia with upper surface flat, with short spine near apex beneath tarsus; tarsus half as long as tibia, first segment shorter than rest combined; claws divaricate.

KEY TO FIJIAN SPECIES OF *Nesohaltica*

1. Pronotum distinctly punctured, smooth and not rugulose 2

   Pronotum uneven, shallowly rugulose, very finely and indistinctly punctured; antenna pale .... **lauensis**

2. Shiny deep brown with a slight metallic tinge; pronotum finely and in part somewhat closely punctured; elytron irregularly punctured, more densely so than pronotum .... **brunnea**

   Shiny black; pronotum finely and sparingly punctured; elytron strongly and somewhat closely punctured.... **vitiensis**

127. *Nesohaltica brunnea* Bryant, n. sp.
Fig. 43

Oblong; shining deep brown with a slight metallic tinge; antenna, legs, and underside paler; prothorax and elytron closely punctured.

Head deep brown, a transverse impression between the eyes, the basal half impunctate and shining; antenna fulvous, extending to the middle of elytron; first segment the longest and dilated at the apex; second much shorter and slightly rounded; remainder more elongate and each about equal, the five terminal slightly thickened. *Prothorax* deep brown with a metallic tinge, transverse, broadest at the base, the sides slightly contracted in front, the anterior angles oblique, closely and finely punctured. *Elytron* deep brown with a metallic tinge, slightly broader than the base of the prothorax, oblong, rounded at the apex, closely and irregularly punctured. *Legs* and underside paler and more fulvous, the posterior femora slightly darker. Length 2 mm.

VITI LEVU: Holotype (BISHOP 2464), Nandarivatu, 850 m., Sept. 8, 1938, beating shrubbery, Zimmerman. One of same data, questionably this species; four paratypes, Lami Quarry, near Suva, May 1951, Krauss, and a fifth specimen from Lami tentatively referred here.

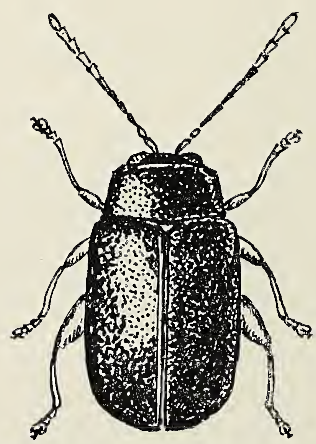

FIG. 43. *Nesohaltica brunnea* Bryant, n. sp., type.

Allied to *N. vitiensis* Bry., and *N. atra* Bry. (New Hebrides), but differs in its color and punctation, in which *brunnea* is intermediate between these two.

128. *Nesohaltica lauensis* Gressitt, n. sp.
Fig. 44

Ochraceous brown, paler on fore and hind margins of pronotum; antenna testaceous; tibiae and tarsi pale ochraceous.

Head triangular and flat on frons, transversely grooved between upper eye lobes, convex and minutely punctured on occiput. *Antenna* one-half as long as body, first two segments about as stout as last few, third to sixth more slender; scape nearly twice as long as second; third to sixth each about as long as second. *Prothorax* two-thirds as long as broad, narrowed from base to apex, nearly straight at side with anterior angle slightly prominent; basal margin evenly convex; anterior border slightly convex; disc uneven, almost entirely roughened or shallowly rugulose, with minute, indistinct punctures. *Scutellum* triangular, smooth and concave. *Elytron* broadest behind middle, broadly rounded apically, irregularly, and rather closely punctured throughout, the punctures mostly as large as interspaces. *Ventral surfaces* in part distinctly punctured. First hind tarsal segment short. Length 1.6 mm.; breadth 0.95 mm.

LAU: Holotype (BISHOP 2465), Namuka-i-lau I., southern Lakemba I. (southcentral Lau Group), Aug. 12, 1924, E. H. Bryan, Jr.

Differs from *N. brunnea* and *vitiensis* Bryant in having the pronotum rough and somewhat rugulose, instead of smooth and distinctly punctured, and the coloration paler. Differs from *N. nigra* Maulik in the same characters, and in having the first two antennal segments much thicker than those immediately following.

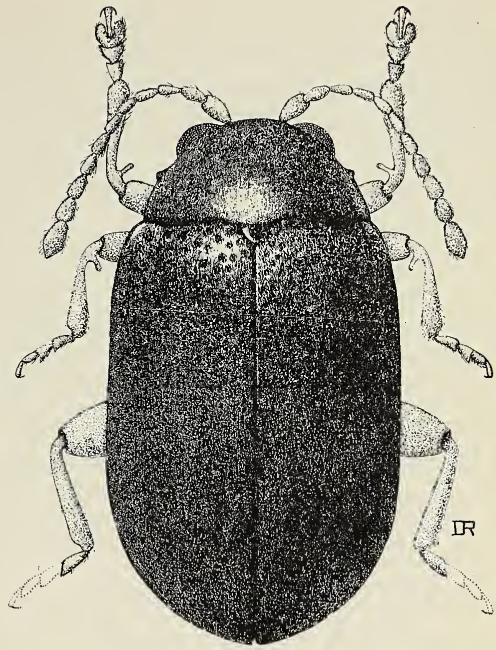

FIG. 44. *Nesohaltica lauensis* Gressitt, n. sp., type.

129. **Nesohaltica vitiensis** Bryant

Nesohaltica vitiensis Bryant, 1938, Roy. Ent. Soc. London, Proc. B 7(11): 251 (Vanua Levu; Taveuni; type in Brit. Mus.).

Shiny black; antenna fulvous with four apical segments fuscous; legs and underside pitchy brown. Head with basal half shiny black, impunctate; frons pitchy brown, a transverse impressed line between eyes; antenna reaching almost to middle of elytron; scape longer and more swollen than second, remainder more slender and subequal. Prothorax shiny black, finely and sparingly punctured, sides slightly rounded and margined, anterior angles obliquely truncate; scutellum shiny black, impunctate, triangular. Elytra shiny black, strongly and somewhat closely punctured, rounded at apex; side margin with a line of evenly spaced punctures which are much stronger than the other elytral punctures. Legs and underside pitchy brown. Length 2 mm.

VANUA LEVU: Lambasa (type locality).
TAVEUNI: Taken on guava.
HOST: *Psidium guajava* Linn.

Genus FEBRA Clark

Febra Clark, 1864, Jour. Ent. 2: 261 (type *F. venusta* Clark; Fiji).

Head vertical in front; vertex slightly grooved medially; eye large; antenna long, with scape long, thickened distally; prothorax transverse, rounded at side; elytron fairly broad, heavily punctured; hind tibia grooved above; first hind tarsal segment shorter than following combined, fairly stout.

KEY TO FIJIAN SPECIES OF *Febra*

1. Pronotum very coarsely punctured, hardly more than ten punctures in an approximate line medially from apex to base; elytron heavily punctured . . **2**

   Pronotum not very coarsely punctured, much more than ten punctures along median line; elytron generally sparsely punctured 3

2(1). Elytral punctures very close, only partly in regular rows; green above . . . . **varioloidea**

   Elytral punctures not extremely close, in separate distinct rows; reddish above . . . . **rubra**

3(1). Third antennal segment much longer than second; elytron not striped; length over 5 mm. 4

   Third antennal segment barely longer than second; elytron striped; length under 4 mm. 5

4(3). Pronotum distinctly punctured; elytron black, very finely punctured. . . . . **insularis**

   Pronotum not distinctly punctured; elytron reddish to partly or entirely metallic blue, subcoarsely punctured . . . . **venusta**

5(3). Pronotum striped medially, minutely punctured; suture not distinctly black basally; elytron not almost entirely black in posterior half . **n. nigroornata**

   Pronotum not striped medially, impunctate; suture distinctly black basally; elytron almost entirely black in posterior half . **nigroornata vanuana**

130. **Febra venusta** Clark

Febra venusta Clark, 1864, Jour. Ent. 2: 262, pl. 12, fig. 5 (Fiji; type in Brit. Mus.).

Febra semiaurantiaca Fairmaire, 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 490 (Ovalau); n. syn.

MALE: Ochraceous, slightly darker on antenna, posterior two-thirds of elytron and hind leg. *Head* and *pronotum* practically impunctate, latter with an irregular transverse row of spaced punctures in basal depression; scape shorter than third segment; *elytron* with punctures distinct but well spaced, in subregular rows. Length 5.5 mm.

FEMALE: Scape longer than third antennal segment; posterior two-thirds of elytron metallic bluish. Length 6 mm.

Maulik indicated the common identity of the above two names by his identification labels; *venusta* being the male and *semiaurantiaca* being the female.

VITI LEVU: Naivithula, Tailevu, Sept. 1937, Valentine, both sexes; Tholo-i-suva, Sept. 1950, Mar. 1951, Krauss.

OVALAU: Type locality of *semiaurantiaca*.

VANUA LEVU: Three, Nakawanga, Oct. 8, 1955, Gressitt. The males are colored similarly to those from Viti Levu, but the female has the elytron entirely purplish blue. Possibly a weak subspecies is involved.

HOST: *Nephrolepis* sp. (fern); the larva is a leaf-miner.

131. **Febra insularis** Bryant
Fig. 45*a*, *b*

Febra insularis Bryant, 1925, Ann. and Mag. Nat. Hist. Ser. 9, 15: 596 (Cuvu; type in Brit. Mus.).

Fulvous; elytra metallic bronze-green with fulvous margin. *Head* vertical and strongly produced in front; frons glabrous; occiput strongly punctured; *antennae* closed inserted; scape equal to third segment; second one-third as long; *prothorax* strongly and irregularly punctured; side with narrow margin with row of six deep punctures; hind margin

a

b

FIG. 45. *Febra insularis* Bryant: *a*, Larva, dorsal view; *b*, larval leaf mine in leaf of *Acrostichum* fern.

strongly emarginate; *elytron* four times as long as prothorax, finely punctate-striate, rounded to apex; *venter* glabrous; tibiae and tarsi briefly pubescent, tibial bases darkened. Length 6 mm.

EGG: White, spherical. Length 0.066 mm. Laid in a slit chewed in side of midrib of fern.

MATURE LARVA: Creamy white; head capsule reddish ochraceous, darker near anterior border and along median line, paler on basal antennal segment and along frontoclypeal suture; pronotum testaceous on central portion except along median line; a dirty broadish median dorsal stripe extending from mesonotum to last abdominal segment, appearing to consist of minute gray transverse sclerotizations on surface. Body about twice as wide as deep. Head flat, trapeziform, narrowed anteriorly, fairly smooth, finely vermiculose on central portion; two short bristles on lateral border behind ocellus-like pale node behind antenna; another bristle below this node. Pronotum rather even and flat, slightly wrinkled on sclerotized portion of disc. Dorsum of remainder of body finely granulose; ventral surfaces similar to dorsal, but median gray stripe lacking and a few well pigmented lines of sclerotization on prosternum and legs. Mesothorax and nine abdominal segments each bearing slightly pigmented spiracle at end of a white fleshy papilla-like mid-lateral projection on each side. Length 7.5 mm.

VITI LEVU: Thuvu (type locality). Between Nausori and Korovou, Sept. 1955, O'Connor, larvae and adults.

HOST: *Acrostichum aureum* (fern); the larva is a leaf-miner (see Fig. 45).

132. **Febra varioloidea** Fairmaire

Febra varioloidea Fairm., 1882, Soc. Ent. de France, Ann. Ser. 6, 1: 490 (Ovalau; type in Paris).

Reddish pitchy, tinged with metallic green on central portion of dorsum, appearing green to naked eye; pitchy to black on elytral declivities and ventral surfaces; appendages partly

reddish. Dorsum very deeply and coarsely punctured on metallic areas, more sparsely so on darker borders; elytral punctures in part tending to form sublongitudinal rows. Length 4 mm.

OVALAU: (type locality); Wainiloka, July 11, 1938, C. M. Cooke, Jr.

133. *Febra rubra* Gressitt, n. sp.
Fig. 46

FEMALE: Reddish ochraceous with a very slight purplish metallic tint on basal antennal segments, pronotum, and base, middle and lateral declivity of elytron.

Head concave in lateral outline anteriorly, with vertex projecting; swollen on each side and grooved medially between eyes, a lesser swelling on each side of occiput. *Antenna* slightly longer than body, slender; scape nearly as long as next two segments combined; third much longer than second; third and fourth subequal, following very slightly shorter. *Prothorax* nearly twice as broad as long, feebly convex on disc, but declivitous at side to margin, coarsely and closely punctured. *Scutellum* subtriangular, rounded behind. *Elytron* more than twice as long as head and prothorax together, coarsely punctured in 11 fairly regular rows, the punctures close longitudinally, but with distinct raised longitudinal interspaces. *Ventral surfaces* feebly punctured. First hind tarsal segment hardly as long as next two combined. Length 3.5 mm.

VITI LEVU: Holotype, female (BISHOP 2466), Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman. Two paratypes, Tholo-i-suva, Mar. and Apr. 1951, Krauss.

Differs from *F. varioloidea* Fairmaire in being reddish ochraceous instead of green above, in having the pronotum less deeply, though almost as coarsely, punctured, and the elytron punctured in distinct longitudinal rows with broad low ridges between the rows instead of densely punctured throughout. The paratypes are tinged with greenish above, and are partly green at sides of pronotum and elytron.

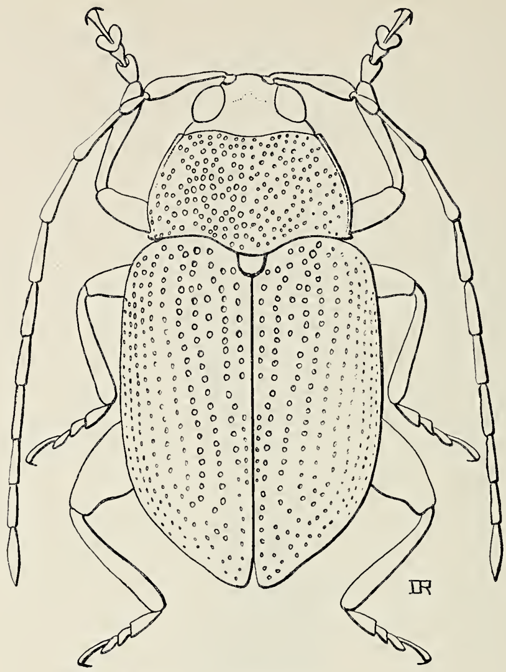

FIG. 46. *Febra rubra* Gressitt, n. sp., type.

134. *Febra nigroornata nigroornata* Bryant, n. sp.
Fig. 47

Oval, convex; flavous, side and median portion of prothorax black, elytron flavous, with a broad longitudinal black marking, broadening from base to apex, not touching side margin.

Head flavous, impunctate, a longitudinal median narrow impression from between antennal insertions to between eyes. *Antenna* long and slender, extending beyond middle of elytron, first segment very long, about equal to second and third together, third slightly longer than fourth, fifth to apical segments all about equal. *Prothorax* transverse, widest at base, contracted in front, impunctate, flavous, sides and base broadly black, and a longitudinal narrow black line, not touching anterior margin. *Scutellum* black, triangular, impunctate. *Elytron* with side rounded, widest just behind the middle, flavous, with the side broadly black, not touching side margin or suture, but broadening from base to apex, punctate-striate. *Legs* flavous; pos-

terior femora black. Underside flavous. Length 3 mm.

VITI LEVU: Holotype (BM, NH), Lautoka, Sept. 13, 1948, R. A. Lever; 2 paratypes, Nandarivatu, 1100 m., Sept. 10, 1938, Zimmerman. Eleven paratypes, Tholo-i-suva, Sept. 1950, Apr. 1951, and Lami Quarry, near Suva, Mar. 1951 and Jan. 1955, Krauss.

Allied to *Febra ovata* Bry., from New Hebrides, but smaller, with pattern different, more nitid, and not so strongly punctured.

135. *Febra nigroornata vanuana* Gressitt, n. subsp.

FEMALE: Testaceous, marked with areas of pitchy black: eye black; occiput black behind eye; pronotum black on outer half of disc, a little more broadly so at apex and base; elytron black except for a broad oblique hyaline strip from just behind middle of base to second quarter of suture, outer margin on basal two-fifths extending inward not quite to center, and external margin narrowly before apex, leaving extreme base, short sutural stripe, broad sinuous humeral stripe, and most of apical half, black; posterior half of hind tibia black.

FIG. 47. *Febra n. nigroornata* Bryant, n. sp., type.

Head smooth, impunctate, subevenly convex between eyes. *Antenna* reaching middle of elytron; scape long and slightly arched, slightly longer than next two segments combined; third barely longer than second, but more slender; fourth longer than third; sixth and following shorter. *Prothorax* smooth and shiny, almost impunctate. *Elytron* distinctly punctured in regular rows, most of punctures on basal half slightly smaller than spaces between them, those on posterior half much smaller. Length 2.8 mm.

VANUA LEVU: Holotype, female (BISHOP 2467), near Nakawanga on trail from Nakawanga to Wailevu, 50 m., Oct. 9, 1955, Gressitt; and paratype, female, same data.

Differs from the typical form from Viti Levu in having the pronotum nearly impunctate, not striped medially, and pale on middle portion of basal margin, the elytron largely black in posterior half, with sutural stripe, more sinuous humeral stripe, and basal margin distinctly black.

Subfamily *HISPINAE*

Genus PROMECOTHECA Blanchard

Promecotheca Bl., 1853, Voyage Pôle Sud Zool. 4: 312 (type: *P. caeruleipennis* Bl.; Tonga).

Head short, about as broad as prothorax; antenna slender, two-thirds as long as body, the segments partly dissimilar in length; prothorax longer than broad, broadened in middle, constricted near base; elytron long, regularly striate-punctate; legs short and stout.

KEY TO FIJIAN SPECIES OF *Promecotheca*

1. Prothorax subparallel-sided in anterior third; pronotal disc more or less impunctate; legs entirely pale; antenna pale basally . . . . **caeruleipennis**

Prothorax distinctly narrowed in anterior third; pronotal disc finely punctured; tibiae, tarsi, and hind femur blue; antenna bluish basally . . . . **bicolor**

136. Promecotheca caeruleipennis Blanchard

Promecotheca caeruleipennis Bl., 1853, Voyage Pôle Sud Zool. 4: 312 (Tonga: Vavao).

Promecotheca Reichii Baly, 1869, Ent. Soc. London, Trans. 1869: 374 (Vavao); new syn.

Promecotheca reichei, Weise, 1911, Coleopt. Cat. 35: 54 (Tonga, Viti); Veitch and Greenwood, 1921, Linn. Soc. N. S. Wales, Proc. 46: 511; Maulik, 1929, Insects of Samoa 4(3): 210, figs. 17, 18 (Samoa); Taylor, 1937, The biological control of an insect of Fiji, Imp. Inst. Ent. pp. 1–239, figs. 1–17, maps 1–2, pls. 1–23; Greenwood, 1940, Linn. Soc. N. S. Wales, Proc. 65: 215; O'Connor, 1949, Agr. Jour. [Fiji] 20(2): 50 (Tonga).

Promecotheca lindingeri Aulmann, 1914, Ent. Rundschau. 31: 27 (Samoa).

Promecotheca caeruleipennis ab. *reichii*, Weise, 1922, Philippine Jour. Sci. 21: 70.

Testaceous; posterior two-thirds of elytron metallic blue-green; abdomen purplish; antenna pitchy distally. *Head* smooth; *prothorax* very slightly broadened in middle, constricted posteriorly, its disc fairly smooth, sometimes with vague and sparse minute punctures; *elytron* punctured in even, regular rows. Length 7–8 mm.; breadth 2–2.6 mm.

This species was stated by Taylor to occur on practically every island of Fiji, and to fluctuate in population, becoming a pest particularly in the Lau Islands. It has been very well controlled by the parasite *Pleurotropis parvulus*.

Fiji, Tonga, Samoa.

HOSTS: *Cocos nucifera* L.; *Pritchardia* (*Eupritchardia*) *pacifica* Seem; *Livistona* sp.

137. Promecotheca bicolor Maulik

Promecotheca bicolor Maulik, 1927, Ann. and Mag. Nat. Hist. Ser. 9, 20: 107, fig. 2 (Viti Levu; type in Brit. Mus.).

Reddish testaceous; antenna bluish; posterior two-thirds of elytron blue-green; abdomen blackish green; tibiae, tarsi, and hind femur greenish. *Head* smooth; antenna slender; *prothorax* distinctly broadened in middle, narrowed apically, strongly constricted near base, its disc finely punctured; *elytron* punctured in regular rows. Length 7–8.5 mm.; breadth 2.5–3 mm.

VITI LEVU: Near Suva (type locality). Lami, Mar. 1951, Tholo-i-suva, Jan. 1955, Krauss; two specimens.

VANUA LEVU: Wainunu, in *Flagellaria*, Sept. 1934, R. W. Paine (Dept. Agr. collect., Koronivia).

HOST: *Flagellaria* sp.

REFERENCES

BALY, J. S. 1869. Descriptions of new genera and species of Hispidae; with notes on some previously described species. *Ent. Soc. London, Trans.* 1869: 363–382.

——— 1877. Descriptions of new species of phytophagous beetles belonging to the family Eumolpidae; and a monograph of the genus *Eumolpus*. *Ent. Soc. London, Trans.* 1877: 37–56.

BLANCHARD, EMILE. 1853. IN: *Voyage Pôle Sud . . . sous J. Dumont d'Urville.* Zoologie, Insectes 4. 422 pp., 12 pls. (See esp. p. 312.)

BOISDUVAL, JEAN A. 1835. Faune entomologique de l'Ocean Pacifique. *Voyage de l'Astrolabe.* Deuxième Partie, Coleopteres. 716 pp. Tastu, Paris. (See esp. p. 548.)

BRYANT, G. E. 1925. New species of Phytophaga from the Fiji Islands. *Ann. and Mag. Nat. Hist. Ser.* 9, 15: 590–600.

——— 1931. New species of Fijian Eumolpidae. *Ann. and Mag. Nat. Hist. Ser.* 10, 8: 355–365, figs. 1–8.

——— 1936. Insects of the New Hebrides: Chrysomelidae. *Ann. and Mag. Nat. Hist. Ser.* 10, 17: 242–256.

——— 1938. New species of Chrysomelidae from Fiji, British North Borneo and Malaya.

Roy. Ent. Soc. London, Proc. B 7(11): 249–252.
——— 1941. New species of Chrysomelidae from New Guinea, Solomon I. and Fiji. *Ann. and Mag. Nat. Hist. Ser.* 11, 8: 96–105, figs. 1, 2.
——— 1942. New species of Chrysomelidae from the Fiji Islands. *Ann. and Mag. Nat. Hist.* 11(9): 508–512.
——— 1943. New species of Cryptocephalinae from Fiji, New Guinea and Solomon Islands. *Ann. and Mag. Nat. Hist. Ser.* 11, 10: 566–571.
——— 1945. New species of Chrysomelidae (Cryptocephalinae, Eumolpinae and Halticinae) from Java and Fiji. *Ann. and Mag. Nat. Hist. Ser.* 11, 12: 421–428, figs. 1–9.
CHAPUIS, F. 1874. Genera des Coléoptères, 10: 1–455 (p. 334, note 1, pl. 122, fig. 4).
——— 1876. Diagnoses de Cryptocephalides inédits appartenant à la faune de l'Australie. *Soc. Ent. de Belg., Ann. Comptes Rendus Comptes Rendus* 19: XCIX—CI.
——— 1877. Diagnoses des espèces du genre *Aulacophora* recuillies aux îles Philippines par le Dr. Semper. *Soc. Ent. de Belg., Ann. Comptes Rendus* 19: XCIX—CI.
CHEN, S. H. 1940. Notes on Chinese Eumolpidae Sinensia 11: 483–528.
CLARK, HAMLET. 1864. Descriptions of new Australian Phytophaga. *Jour. Ent.* 2(11): 247–263, pl. 12.
EVANS, J. W. 1952. *The injurious insects of the British Commonwealth.* Commonwealth Inst. of Ent. London. vii, 1–242.
FAIRMAIRE, LEON. 1879. Diagnoses des Coléoptères Australiens et Polynésiens. *Le Naturaliste* 1(10): 75–76.
——— 1882. Essai sur les Coléoptères des îles Viti (Fidgi). *Soc. Ent. de France, Ann. Ser.* 6, 1: 461–492.
GREENWOOD, WILLIAM. 1940. The food-plants or hosts of some Fijian insects, IV. *Linn. Soc. N. S. Wales, Proc.* 65: 211–218.
GRESSITT, J. L. 1955. Coleoptera: Chrysomelidae. *Insects of Micronesia* [Bernice P. Bishop Museum, Honolulu] 17(1): 1–60, figs. 1–19.
——— 1956. Some distribution patterns of Pacific island faunae. *Systematic Zoology* 5(1): 11–32, 47; 9 maps.
JEPSON, F. P. 1911. Report on economic entomology. *Fiji Dept. Agr., Council Paper* 25: 1–89.
KASZAB, Z. 1955. Tenebrioniden der Fiji-Inseln. Hawaii. Ent. Soc., Proc. 15(3): 423–563, map, figs. 1–201.
KNOWLES, G. H. 1907. Legislative Council Paper, Fiji, No. 13. Report for 1906.
LADD, H. S. 1934. Geology of Vitilevu, Fiji. *Bernice P. Bishop Museum, Bul.* 119: iii, 1–263, figs. 1–11, pls. 1–44.
LEVER, R. J. A. W. 1942. Entomological notes. *Fiji Dept. Agr., Agr. Jour.* 13(2): 48–49.
——— 1946. Insect pests in Fiji. *Fiji Dept. Agr., Bul.* 23: i–v, 1–36, pls. 1–8, 1 map.
MAULIK, S. 1927. Two new Hispinae from Fiji and New Britain. *Ann. and Mag. Nat. Hist. Ser.* 9, 20: 105–108, figs. 1, 2.
——— 1929. Chrysomelidae. *Insects of Samoa* [Brit. Mus., Nat. Hist.] 4(3): 177–215, figs. 1–18.
——— 1937. Distributional correlation between hispine beetles and their host-plants. *Zool. Soc. London, Proc.* A 1937(2): 129–159.
MAYR, ERNST. 1941. Borders and subdivisions of the Polynesian region based on our knowledge of the distribution of the birds. *Sixth Pacific Sci. Congress, Berkeley, Proc.* 4: 191–195.
MYERS, G. S. 1953. Ability of amphibians to cross sea barriers, with special reference to Pacific zoogeography. *Seventh Pacific Sci. Congress, N. Z., Proc.* 4: 19–27.
TAYLOR, T. H. C. 1937. The biological control of an insect in Fiji: An account of the coconut leaf-mining beetle and its parasite complex. *Imp. Inst. Ent.* London. Pp. 1–239, figs. 1–17, pls. 1–23.
VEITCH, ROBERT, and WILLIAM GREENWOOD. 1921. The food plants or hosts of some Fijian insects. *Linn. Soc. N. S. Wales, Proc.* 46: 505–517.

An Annotated List of Marine Algae from Eniwetok Atoll, Marshall Islands[1]

E. Yale Dawson[2]

The following account is based largely upon collections made by the writer at Eniwetok during the late summer of 1955 and upon collections made on several occasions prior to that time by Dr. Ralph F. Palumbo of the Applied Fisheries Laboratory, University of Washington. The object of the work has been the preparation of a reference collection of algae of the atoll for deposition at the Eniwetok Marine Biological Laboratory (EMBL), where it may be consulted by future biological investigators interested in identifying algal research materials.

There exist only three previous accounts of Eniwetok marine algae, namely, Taylor's *Plants of Bikini* . . . (1950) which treats of 67 species, Palumbo's (1950) brief listing of a few entities, most identified only to genus, and Odum and Odum's (1955) mention of four species by name. The most comprehensive list of Marshall Islands algae to date has just been published by the writer (1956) in *Pacific Science.* It treats of 149 species (exclusive of Myxophyta) for the southern Marshall Islands. All but 43 of these are again listed in the present account, which includes 228 species and varieties. Of these, 36 are Myxophyta, 79 Chlorophyta, 20 Phaeophyta, and 91 Rhodophyta.

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Inasmuch as this paper can be of greatest service as an aid to the identification of the algae occurring at Eniwetok, a key to all of the genera is included as well as an illustration for each species of Green, Brown, and Red Algae for which a figure is not to be found among the following accounts of tropical Pacific marine algae: Taylor, 1950; Dawson, 1954; Dawson, 1956. If these three papers are employed in conjunction with the present list, one should find it relatively easy to identify a great majority of the species encountered.

It should be noted that the key to the genera is intended to apply specifically to those algae recorded here from Eniwetok Atoll. It does not necessarily apply to species of those genera from other regions.

The short glossary of certain special phycological terms is intended to aid those of other disciplines in the use of the key.

ACKNOWLEDGMENTS

Nearly all of the algal collections cited here other than the writer's were made by Dr. Ralph F. Palumbo, who kindly contributed much time in preparing them for study in Honolulu. The list is considerably more comprehensive as the result of the availability of his specimens, which provide an excellent supplement to mine.

Dr. Francis Drouet provided identifications for all of the Blue-green Algae, so that this

part of the list may be considered entirely his own contribution.

Dr. Harold St. John kindly prepared the Latin diagnoses of new taxa.

Special thanks are due to Dr. Robert W. Hiatt for making all the arrangements for carrying out this study, and to Dr. Maxwell S. Doty for the use of his library and other facilities in Honolulu. Several others contributed help in various ways, especially Mr. Malvern Gilmartin, Mr. A. Dexter Hinckley, Mr. Robert T. B. Iversen, Mr. James Stewart, Dr. Donald W. Strasburg, and Dr. A. J. Bernatowicz.

Photographs are by Mr. George Edelman.

COLLECTING LOCALITIES

Inasmuch as a number of variations occur in the spelling and application of the names of islands in Eniwetok Atoll, a list is presented here to show the equivalents. The list follows the succession of islands in a clockwise manner, beginning with Bogallua in the northwest part of the Atoll. The first name given in each case is that used in the text and in the labeling of specimens, followed by some common variations which may be encountered on United States maps and in geographical publications.

Bogallua
Bogombogo
Eneroul = Eybbiye = Ruchi (often treated as a single island with the next)
Runo = Eybbiye = Ruchi = Cochiti
Bokanjoio = Sanildefenso
Elugelab
Lidilibut = Teiteiripucchi
Bogairik = Bogeirik
Bokaniuar
Bogon
Engebi
Muzin = Mujinkarikku
Kirinian = Biilee
Bokonaarappu
Yeiri
Aitsu
Rujoru = Lujor = Pujiyoru = Rujiyoru
Eberiru
Aomon = Aranit
Biijiri = Biiziri
Rojoa
Aaraanbiru = Arambiru
Piiraai
Runit
Enedrol
Chinieero
Aniyaanii = Japtan
Chinimi
Japtan = Muti
Bogen = Boken = Jieroru
Parry
Eniwetok
Igurin
Mui = Buganegan
Pokon = Bogan
Ribaion = Libiron = Ribairon
Giriinien = Grinem
Rigili

The following is a complete list of the writer's collections made during August and September 1955. The inclusive field collection numbers precede the locality data in each case. It should be noted that where these numbers are cited in the text they are prefixed by "D." Collection numbers by Palumbo are prefixed by "P.," and, because of their smaller number and scattering in time and space, are provided with locality data in the text. Those collections by Taylor which represent species not again collected are cited by his field number prefixed by "T."

A specimen of each of the Dawson and Palumbo collections cited here is deposited in the Eniwetok Marine Biological Laboratory, with the exception of the type specimens of new species and varieties, which are deposited in the Bernice P. Bishop Museum in Honolulu.

13607–13654. Parry Island, outer seaward reef opposite EMBL, Aug. 19.

13655–13679. Parry Island, seaward reef flat between EMBL and south end of island, Aug. 20.

13680–13692. Parry Island, seaward reef flat at extreme south end of island, Aug. 21.
13693. Parry Island, drift in front of EMBL, Aug. 21.
13694–13712. Parry Island, among coral heads in the lagoon near south end of island in 6 to 10 feet of water, Aug. 21.
13713–13716. Aniyaanii Island, inshore lagoon near landing, Aug. 22.
13717–13745. Aniyaanii Island, seaward reef just on or inside of coralline ridge, Aug. 22.
13746–13781. Aniyaanii Island, under coral and rocks in tidal washes at north side of island, Aug. 22.
13782–13798. Aniyaanii Island, lagoon side among coral heads in 3 to 8 feet of water, Aug. 22.
13799–13824; 13855–13858a. Engebi Island, ocean side reef, Aug. 23.
13825–13827. Engebi Island, on a boulder in middle of ocean side reef, Aug. 23.
13828. Engebi Island, lagoon side drift, Aug. 23.
13829–13854. Engebi Island, algal mat area on dead coral and sand bottom of lagoon side, Aug. 23.
13859–13874. Igurin Island, seaward reef, Aug. 24.
13875–13877. Igurin Island, at depth of 20 feet off edge of seaward reef, Aug. 24.
13378. Igurin Island, sand flat on sea side, Aug. 24.
13879–13880. Igurin Island, seaward reef drift, Aug. 24.
13881–13885. Igurin Island, lagoon side drift near north end, Aug. 24.
13888–13897. Igurin Island, mid-island lagoon in 3 to 6 feet of water, Aug. 24.
13893–13899. Runit Island, lagoon side bottom at about 8-foot depth, Aug. 25.
13900–13908. Runit Island, scraped from a *Tridacna* shell from 20-foot depth in the lagoon, Aug. 25.
13909–13910. Runit Island, lagoon side drift, Aug. 25.
13911–13916. Runit Island, from vertical sides of pier piles in the lagoon, Aug. 25.
13917–13925. Runit Island, on a floating bumper log fastened to the pier, Aug. 25.
13926–13936; 13940–13946. Runit Island, ocean reef flat, Aug. 25.
13937–13939. Runit Island, in the lagoon in 10 feet of water, Aug. 25.
13947–13954. Parry Island, in the lagoon among coral heads in 10 to 12 feet of water, Aug. 28.
13955–13956. ¾ mile off Aniyaanii Island, on lagoon bottom in 90 feet (drift), Aug. 29.
13957–13961. Parry Island, lagoon beach in 6- to 8-foot depths, Aug. 29.
13962–13970. ½ mile off Aniyaanii Island, around and on a dead coral head in the lagoon at 35- to 65-foot depths, Aug. 30.
13971. Parry Island, off lagoon swimming beach in 10 feet of water, Aug. 30.
13972–13983. Parry Island, in end of pipe and beneath outfall of salt water from generating plant opposite EMBL, Aug. 30.
13984–13995. Japtan Island, reef along passage opposite Parry Island, Aug. 30.
13996–14000. 1½ miles off Aniyaanii Island, lagoon bottom at a depth of 135 feet, Aug. 31.
14001–14020. Rigili Island, seaward reef near edge at north end of island, Sept. 2.
14021–14032. Rigili Island, sand bottom in lagoon in 3 to 6 feet of water, Sept. 2.
14033–14039. Rigili Island, at small island on lagoon side subject to prevailing winds, Sept. 2.
14040–14041. Rigili Island, seaward reef, Sept. 2.
14042–14043. Parry Island, lagoon swimming area, Sept. 3.
14044–14053. Parry Island, on and around tanker wreckage adjacent to passage, Sept. 3.

GLOSSARY

chromatophore: a pigment-bearing structure within the cell.
corticated: provided with a complete or incomplete layer of superficial cells over the primary axis of the thallus.

distichous: disposed in two vertical rows; two ranked.
endophytic: growing within another plant.
epiphytic: growing on another plant.
heterocysts: cells which are uniformly dissimilar in shape and (or) size from their neighbors.
intercalary: inserted between, as opposed to terminal or basal.
medulla: the central or inner tissue of a thallus as opposed to the cortex.
midrib: a vein-like or rib-like thickened axis of a blade.
monosporangium: an asexual reproductive organ in the red algae which produces a single spore.
multifarious: disposed in many ranks about an axis.
multiseriate: of more than a single row of cells.
rhizoidal filaments: thick-walled, very long cells of exceedingly small diameter running vertically between the larger cortical cells as in *Gelidium*.
rhizoids: small root-hair-like unicellular or multicellular outgrowths for attachment.
saxicolous: growing on rocks.
stichidium: a club-shaped reproductive branch in the red algae producing tetrasporangia.
tetrasporangium: an asexual reproductive organ in the red algae which produces spores in groups of four.
trabeculae: bars or strands running from one side of a coenocytic thallus to the other, as in *Caulerpa*.
trichoblast: a branched, colorless, hair-like outgrowth produced around the apex of certain red algae, usually soon falling away.
trichome: the individual cellular filament of a multicellular blue-green alga, not including the sheath.
tristichous: disposed in three vertical rows; three ranked.
uniseriate: of a single row of cells.
utricles: the enlarged, bladder-like ends of the filaments of *Codium* which are arranged to make up the surface layer of the thallus.

KEY TO THE GENERA OF MARINE ALGAE OF ENIWETOK

1. Plants unicellular, or apparently so, macroscopic or microscopic, spheroidal, ellipsoidal or club-shaped 2
1. Plants multicellular, or, if noncellular the thalli macroscopic and not solid spheroidal, ellipsoidal or club-shaped . 8
2. Plants microscopic, less than 40 μ in diameter, in pairs or colonies within a gelatinous matrix or sheath, sometimes (in *Entophysalis*) arranged in short filaments 3
2. Plants macroscopic, bladder-like 7
3. Colonies showing no particular orientation into basal and apical regions 4
3. Colonies showing orientation of cells into basal and apical regions . . . . **Entophysalis (deusta)**
4. Colonies without definite shape; cells symmetrically ellipsoidal 5
4. Colonies with a definite shape; cells pear-shaped . . . . **Gomphosphaeria**
5. Cells spheroidal, or hemispheroidal when divided 6
5. Cells elongate ellipsoidal . . . . **Coccochloris**
6. Cells usually single or paired, enclosed in a thick, gelatinous sheath . **Anacystis**
6. Cells forming colonies within a gelatinous matrix . . **Entophysalis (conferta)**
7. Thalli spheroidal, attached by small unbranched rhizoids cut off by a septum from the main cell . . . . **Valonia (ventricosa)**
7. Thalli short club-shaped, attached by branched, nonseptate rhizoids . . . . **Boergesenia**
8. Thalli multicellular or noncellular, branched if uniseriate 9
8. Thalli multicellular, but each filament consisting of only an unbranched row of cells (the false branching in *Plectonema* and *Scytonema* is the result of protrusion of a broken trichome through a rupture in the sheath) 99

9. Thalli not minute borers through calcareous material **10**
9. Thalli boring through coral, shell and other calcareous material . . **Ostreobium**
10. Thalli calcified, either completely so as to become hard and stony, or incompletely so as to appear limy **11**
10. Thalli not calcified **24**
11. Thalli essentially prostrate, crustose; if erect branches present, these inflexible and stony **20**
11. Thalli erect and flexible, not prostrate or crustose **12**
12. Thalli not parasol-shaped **13**
12. Thalli shaped like a small parasol . . . . **Acetabularia**
13. Thallus parts of cylindrical shape . . . **14**
13. Thallus parts flat or flattened **18**
14. Thalli branched **15**
14. Thalli unbranched (as viewed macroscopically) . . . . **Neomeris**
15. Thalli distinctly jointed **17**
15. Thalli not distinctly jointed **16**
16. Thalli soft and lubricous . . . . . **Liagora**
16. Thalli firm, not lubricous . . . **Galaxaura**
17. Thalli large and coarse, the segments 2 to several mm. in diameter . . . . **Halimeda (monile** forms)
17. Thalli small and delicate, the segments less than ½ mm. in diameter . . . . **Jania**
18. Thalli not jointed, fan-shaped **19**
18. Thalli jointed . . . . **Halimeda** (except **monile** forms)
19. Thalli brownish, with prominent concentric banding . . . . **Padina**
19. Thalli greenish, not prominently banded concentrically . . . . **Udotea**
20. Thalli forming thin, adherent crusts . **21**
20. Thalli forming massive, stony crusts, sometimes with erect knobs or branches . . . . **Porolithon**
21. Thalli epiphytic, very delicate **22**
21. Thalli saxicolous, coarser **23**
22. Thalli in surface view with frequent larger cells (heterocysts) among the otherwise uniform cells . . . . . . **Fosliella**
22. Thalli in surface view composed of uniform cells . . . . **Heteroderma**
23. Underside of thallus of many fan-shaped groups of cells converging and diverging irregularly . . . . **Cruoriella**
23. Underside of thallus of essentially parallel cell rows . . . . **Peyssonelia**
24. Thalli filamentous, membranous, or massive, but in any case divided up into cells by cross walls **31**
24. Thallus parts not divided up in a cellular manner by cross walls **25**
25. Filaments composing thalli dichotomously branched **26**
25. Thalli, or filaments composing thalli, not dichtomously branched **29**
26. Filaments growing together to form a flabellate or peltate, spongy plant body **27**
26. Filaments free, not forming a spongy plant body **28**
27. Main forked filaments bearing numerous terminally pronged lateral branchlets . . . . **Rhipilia**
27. Main forked filaments without such terminally pronged lateral branchlets . . . . **Avrainvillea**
28. Filaments over 100 μ in diameter above, tending to be larger above than below, not attenuated . . **Pseudochlorodesmis**
28. Filaments usually under 50 μ in diameter above, attenuated or at least of lesser diameter above than below . . **Derbesia**
29. Thallus parts spongy, composed of interlaced filaments forming a surface layer of swollen utricles . . . . . . **Codium**
29. Thallus parts not spongy, without a surface layer of swollen utricles **30**
30. Thalli consisting of basal, cylindrical rhizoid-bearing parts and erect, specialized branches of distinctive shapes; interior of thallus criss-crossed by trabeculae . . . . **Caulerpa**
30. Thalli consisting of erect axes bearing pinnate or multifarious branches; interior without trabeculae . . . . **Bryopsis**

31. Thallus essentially of a single branched row of cells 32
31. Thallus filamentous, membranous or massive, consisting of more than a single, branched row of cells 51
32. Filaments prostrate, spreading; plants microscopic, epiphytic or endophytic . . . . Entocladia
32. Not as above; filaments free and more or less erect 33
33. Individual cells mostly essentially cylindrical and symmetrical except for curvature 35
33. Individual cells asymmetrical, mostly not cylindrical 34
34. Cells protruding irregularly on all sides from the axes . . . . Siphonocladus
34. Cells inflated, irregularly clavate to subovate, in short, more or less repent series of only a few cells . . . . Valonia (in part)
35. Thallus filaments branched in one plane in a fan-, or blade-like manner, at least in part 36
35. Thallus filaments variously branched, but not forming fan- or blade-like parts 38
36. Filaments palmately branched . . . . Rhipidiphyllon
36. Filaments not palmately branched; blades of net-like form 37
37. Blades stalked . . . . Struvea
37. Blades without a definite stalk . . . . Microdictyon
38. Branches essentially free, not attached to each other 39
38. Branches attached to each other by small, specialized cells . . . . . . Boodlea
39. Branching opposite or whorled, at least on main or lower axes 40
39. Branching alternate or irregular, multifarious 41
40. Axes with whorled branchlets; tetrasporangia surrounded by curved filaments . . . . Wrangelia (argus)
40. Main axes (sometimes prostrate) with opposite and distichous or tristichous branchlets; tetrasporangia not associated with curved filaments . . . . Antithamnion
41. Cell wall about as thick as cell cavity, at least in lower parts 42
41. Cell cavity much greater in diameter than cell wall thickness 43
42. Cell cavities oval, longer than broad . . . . Asterocytis
42. Cell cavities more or less quadrangular, broader than long . . . . . Goniotrichum
43. Thalli brownish or reddish, bearing specialized external reproductive structures 46
43. Thalli greenish, without specialized external reproductive structures 44
44. Filaments bearing septa at base of branches 45
44. Filaments mostly, or commonly, without septa at base of branches . . . . Cladophoropsis
45. Filaments coarse, 1–2 mm. in diameter . . . . Valonia (fastigiata)
45. Filaments 0.3–1.0 mm. in diameter . . . . Valoniopsis
45. Filaments delicate, less than 200 μ in diameter . . . . Cladophora
46. Thalli brownish, commonly reproducing by means of multicellular gametangia . . . . Ectocarpus
46. Thalli reddish, commonly reproducing by means of tetrasporangia or monosporangia 47
47. Minute epiphytes with main axes less than 15 μ in diameter 48
47. Epiphytic or saxicolous, but main axes over 70 μ in diameter 49
48. Chromatophores stellate . . . . . . Kylinia
48. Chromatophores not stellate . . . . Acrochaetium
49. Asexual reproduction by tetrasporangia 50
49. Asexual reproduction by monosporangia . . . . Neomonospora

50. Branching regularly alternate and generally spirally arranged; axes less than 100 μ in diameter..... **Callithamnion**
50. Branching irregular; axes over 100 μ in diameter.................. **Griffithsia**
51. Thalli consisting of a subcylindrical axis bearing coarse, angular, toothed lateral branches.......... **Turbinaria**
51. Thalli not as above...............52
52. Thallus net-like, at least in part....53
52. Thallus not net-like..............55
53. Thallus reddish, delicate, flat or four-sided..........................54
53. Thallus brown, coarse, convoluted.... .... **Hydroclathrus**
54. Net-like parts formed as part of flabellate blades.............. **Hemitrema**
54. Entire thallus a four-sided net-like form around a central axis....... **Dictyurus**
55. Thallus cushion-shaped or subspherical, solid or hollow, with cells of macroscopic size.......... **Dictyosphaeria**
55. Thallus not as above; cells not of macroscopic size...................56
56. Thallus hollow-tubular or with hollow, vesicular or tubular parts..........57
56. Thallus without hollow parts......62
57. Thallus without regular constrictions or cavity partitions.................58
57. Thallus regularly constricted and with partitions across the cavity at the constrictions................. **Champia**
58. Thalli hollow essentially throughout.. 59
58. Thalli consisting of a short, solid stipe bearing one or more hollow vesicles... .... **Botryocladia**
59. Thallus parts long and slender compared to diameter................60
59. Thallus parts short and inflated compared to diameter....... **Rosenvingea**
60. Thalli reddish; the tube wall composed of several cell layers..............61
60. Thalli greenish; the tube wall composed of a single layer of cells....... .... **Enteromorpha**
61. Tetrasporangia borne in swollen, terminal stichidia........... **Coelothrix**
61. Tetrasporangia borne in sunken cavities in the branches.......... **Lomentaria**
62. Thalli flat or markedly flattened, at least in part.....................63
62. Thalli essentially cylindrical (sometimes moderately compressed as in *Hypnea*) 75
63. Thalli brownish or reddish, not green, of more than one layer of cells, at least at the midrib if present 64
63. Thalli green, of a single layer of cells throughout............ **Anadyomene**
64. Thallus with a midrib (note that the flattened blade part is very narrow in *Taenioma*) 65
64. Thallus without a midrib..........67
65. Color reddish; branching not at all dichotomous....................66
65. Color brownish; branching subdichotomous............... **Dictyopteris**
66. Apices with two or three terminal hairs .... **Taenioma**
66. Apices with a naked apical cell....... .... **Hypoglossum**
67. Thallus surface covered with tufts of soft but mostly erect filaments....... .... **Dasyopsis**
67. Thallus surface without tufts of filaments........................68
68. Thalli prostrate and fastened by the lower surface...................69
68. Thalli essentially erect, free, not prostrate..........................71
69. Thalli brown...................70
69. Thalli red............. **Rhodymenia**
70. Thalli fan-shaped........ **Pocockiella**
70. Thalli dichotomously branched....... .... **Dictyota (patens)**
71. Growing points not in apical pits...72
71. Growing points in apical pits........ .... **Laurencia (parvipapillata)**
72. Growing point consisting of a single apical cell......................73

72. Growing point without a distinguishable apical cell . . . . **Grateloupia**
73. Thalli small, narrow, less than 1 cm. tall; medulla of several layers of small cells 74
73. Thalli moderately large, 3–10 cm. tall; medulla of a single layer of large cells . . . . **Dictyota** (in part)
74. Medulla with rhizoidal filaments running through it . . . . **Gelidium**
74. Medulla without rhizoidal filaments running through it . . . . **Gelidiella (bornetii)**
75. Axes and branches all similar in appearance and structure 80
75. Axes distinct from ultimate branchlets in appearance and structure 76
76. Branchlets produced in whorls . . . . **Wrangelia** (in part)
76. Branchlets produced alternately or irregularly 77
77. Branchlets not banded 78
77. Branchlets banded . . . . **Spyridia**
78. Branchlets multiseriate; plants rather large, 6–12 cm. tall . . . . . **Asparagopsis**
78. Branchlets uniseriate; plants small, usually less than 2 cm. tall 79
79. Main axes completely or incompletely corticated . . . . **Dasya**
79. Main axes uncorticated . . . . **Heterosiphonia**
80. Thallus parts of essentially uniform cell structure throughout; not banded although sometimes appearing segmented 81
80. Thallus parts provided with discontinuous cortication in the form of bands around a large axial cell row, the bands usually close together above and well separated below . . . . **Ceramium**
81. Thalli of various reddish and brownish colors, but not grass green 82
81. Thalli grass green in color, entangled . . . . **Enteromorpha (ralfsii)**
82. Branches provided with whorls of short, tooth-like spines, at least in part . . . . **Centroceras** (in part)
82. Branches without whorls of spines . . 83
83. Middle and upper thallus parts showing only a few cells (2–5) across the diameter when seen in surface view 84
83. All thallus parts showing many (10 or more) small cells across the diameter when seen in surface view 89
84. Branches termination in a large apical cell of nearly the same diameter as the filament bearing it . . . . **Sphacelaria**
84. Branches terminating in an apical cell which is much smaller than the diameter of the filament bearing it 85
85. Thalli with definite axes provided with dense, multifarious, divaricately branched short branchlets which in mature plants become attached to each other . . . . **Tolypiocladia**
85. Branching not as above 86
86. All branches essentially of unlimited growth 87
86. Branches of potentially unlimited growth alternating with groups of branches of definitely limited growth . . . . **Herposiphonia**
87. Erect filaments arising from extensive prostrate creeping filaments . . . . **Lophosiphonia**
87. Without extensive prostrate filaments 88
88. Mature filaments composed of cells in tiers of three . . . . **Falkenbergia**
88. Mature filaments composed of cells in tiers of four or more . . . . **Polysiphonia**
89. Surface cells not arranged in regular rows, nor the thallus appearing segmented 90
89. Surface cells arranged in horizontal and vertical rows and the thallus appearing somewhat segmented . . . . **Centroceras (apiculatum)**
90. Thallus without a central core of small cells in the medulla 91
90. Thallus in cross section showing a core of very small cells in the center of the medulla . . . . **Dicranema**

91. Medullary cells all similar and more or less isodiametrical in cross section. . **92**
91. Thallus in cross section showing minute rhizoidal filaments between the medullary cells . . . **Gelidium (crinale)**
92. Growing points consisting of an apical cell, either emergent or in an apical pit **95**
92. Apices without a single apical cell . . . **93**
93. Branching irregular, but not markedly divaricate; thalli very slender and wiry **94**
93. Branching markedly divaricate; thalli moderately coarse and succulent . . . . **Chnoospora**
94. Tetrasporangia and antheridia borne in swollen, terminal stichidia; thalli forming small tufts and clumps; main branches mostly 175–250 μ in diameter . . . . **Gelidiopsis**
94. Reproduction not to be expected; thalli forming wiry mats; main branches (100) 140–230 μ in diameter. . **Wurdemannia**
95. Apical cell in a terminal pit **96**
95. Apical cell emergent **97**
96. Thalli erect or with creeping and erect branches, with many very short ultimate branchlets . . . . **Laurencia** (in part)
96. Thalli creeping, with few very short ultimate branchlets . . . . **Chondria (repens)**
97. Thalli minute, mostly under 2 mm. high **98**
97. Thalli larger, 1–3 cm. high . . . **Hypnea**
98. Growing points without trichoblasts . . . . **Gelidiella (tenuissima)**
98. Growing points provided with short trichoblasts . . . . **Chondria** (in part)
99. Individual filaments (trichomes) tapering from base to apex **100**
99. Individual filaments not tapered, of approximately equal diameter throughout **101**
100. With intercalary heterocysts . **Calothrix**
100. With basal heterocysts . . . . . . **Rivularia**
101. Filaments epiphytic, erect, attached by a single, modified basal cell . . . . **Erythrotrichia**
101. Filaments epiphytic or saxicolous, but entangled and without any evident specialized basal attachment cell on individual filaments **102**
102. Filaments with false branching by protrusion of trichomes through breaks in the sheath; heterocysts present or absent **103**
102. Individual filaments without false branching **104**
103. Heterocysts present . . . . . . **Scytonema**
103. Heterocysts not present. . **Plectonema**
104. Heterocysts present. **Hormothamnion**
104. Heterocysts not present **105**
105. Without a sheath around the uniseriate filament **106**
105. Uniseriate filaments surrounded by a sheath **109**
106. Filaments straight or curved, but not spirally coiled **107**
106. Filaments spirally coiled . . . . **Spirulina**
107. Cells very short, less than half as long as broad . . . . **Oscillatoria**
107. Cells not very short, generally longer than broad; filaments generally over 20 μ in diameter **108**
108. Filaments 20–30 μ in diameter . . . . **Rhizoclonium**
108. Filaments 60–90 μ in diameter . . . . **Chaetomorpha**
109. Cells very short, less than half as long as broad **110**
109. Cell length about equal to or greater than breadth **111**
110. Sheaths distinct, firm; trichomes single within the sheath . . . . **Lyngbya**
110. Sheaths more or less mucous, diffluent; trichomes several within the sheath . . . . **Hydrocoleum**
111. Trichomes single within the sheath **112**
111. Trichomes many within the sheath, at least in older parts **115**
112. Trichomes 3 μ or less in diameter . . **113**

112. Trichomes 5 μ or more in diameter . **114**
113. Plant body a light colored, cushion-shaped form . . . . **Phormidium (crosbyanum)**
113. Plant body a dark colored stratum . . . . **Symploca (laete-viridis)**
114. Plant body an erect, spongy, brush-like tuft . . . . **Symploca (muscorum)**
114. Plant body a loose, soft group of short, gelatinous strings . . . . **Phormidium (penicillatum)**
115. Apical cell blunt-conical . . **Schizothrix**
115. Apical cell acutely conical . . . . **Microcoleus**

SYSTEMATIC LIST

GREEN ALGAE

Enteromorpha acanthophora Kützing?
D. 13920a. A few small bits of uncertain identity.

Enteromorpha clathrata (Roth) J. Agardh; Dawson 1954: 384, fig. 6d, e; Dawson 1956: 27
D. 13961.

Enteromorpha intestinalis (Linnaeus) Link; Dawson 1954: 383, fig. 6c
D. 13917.

Enteromorpha kylinii Bliding; Dawson 1954: 384, fig. 5; Dawson 1956: 27
D. 13826. P. 2846, Bokanjoio Is. boat passage at 6 ft., 9/30/54.

Enteromorpha ralfsii Harvey; Dawson 1956: 27, fig. 2
D. 13792, 14024. P. 1187, Bokanjoio Is. tide flats, 4/14/54; P. 2849, Bokanjoio Is. seaward tide flats, 9/29/54; P. 18150, Runo Is. tide flat pool, 2/10/55.

Enteromorpha tubulosa (Kützing) Kützing; Dawson 1954: 384, fig. 6a, b
D. 13920.

Valonia aegagropila C. Agardh; Dawson 1954: 388, fig. 8j; Dawson 1956: 28; Taylor 1950:41
D. 13610, 13736, 13930, 14039.

Valonia fastigiata Harvey ex J. Agardh 1887: 101 (Ceylon)
Fig. 1

P. 29x, Mui Is. seaward tide flats under rocks in large clumps, 3/11/54.

This compares well with the species as understood by Egerod (1952) and with Kanda's fig. 9A (1944) of a plant from Koror.

Valonia utricularis (Roth) C. Agardh; Dawson 1956: 28, fig. 3
P. 7, Rigili Is. under rocks, 8/10/49; P. 2836c, Parry Is. seaward reef edge, 4/4/54.

Valonia ventricosa J. Agardh; Dawson 1954: 388, fig. 8e; Dawson 1956: 28
D. 13751, 13927, 14002.

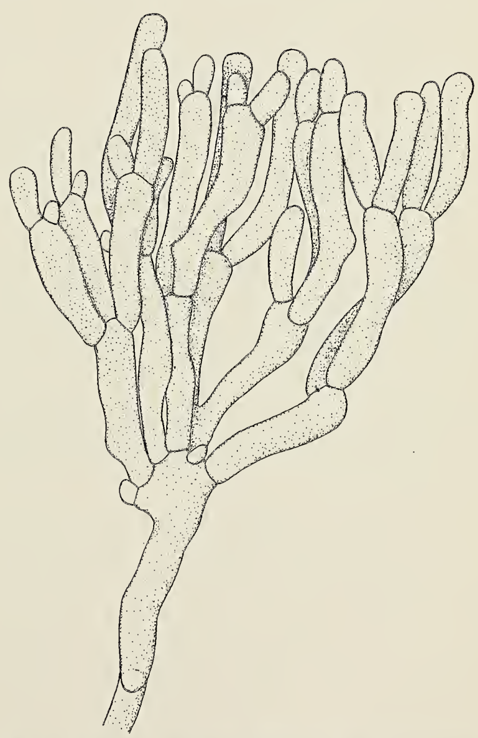


FIG. 1. *Valonia fastigiata*: Habit of part of a plant of P. 29x, × 2.5.

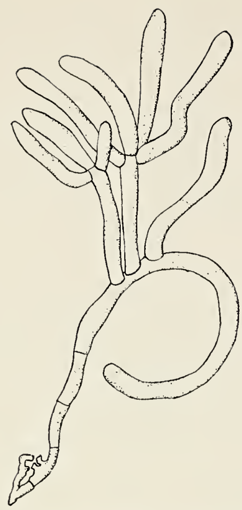


FIG. 2. *Valoniopsis pachynema*: Part of a plant to show branching and septation, × 5 (after Børgesen).

Valoniopsis pachynema (Martens) Børgesen 1934: 10, figs. 1, 2; Taylor 1950: 42. *Bryopsis pachynema* Martens 1866: 24, pl. 4, fig. 2 (Sumatra)

Fig. 2

T. 46–379. Not collected again.

Boergesenia forbesii (Harvey) Feldmann; Dawson 1954: 388, fig. 8d; Taylor 1950: 41 (as *Valonia forbesii* Harv.)
D. 13732.

Dictyosphaeria cavernosa (Forskål) Børgesen; Taylor 1950: 43, pl. 27, fig. 2; Dawson 1954: 388, fig. 8i; Dawson 1956: 29
D. 13758, 14009.

Dictyosphaeria intermedia var. *intermedia* Weber van Bosse 1905: 14; Taylor 1950: 42; Dawson 1956: 29

Fig. 3

D. 13719. P. 2825, Runo Is. seaward reef edge, 3/8/55.

Dictyosphaeria versluysii Weber van Bosse; Dawson 1954: 388, fig. 8k, l; Dawson 1956: 29
D. 13753, 13675. P. 2821, Bokanjoio Is. seaward reef edge, 3/8/55.

Cladophoropsis gracillima Dawson, prox.; Dawson 1956: 30, fig. 7a, b
D. 14049. The material approaches this species closely but does not agree as fully as the specimens reported from Arno Atoll. The filaments are about 40 μ in diameter and have cells 25–50 diameters long.

Cladophoropsis sundanensis Reinbold; Dawson 1956: 30, fig. 8; Dawson, Aleem, and Halstead 1955: 10
D. 13909.

Siphonocladus rigidus Howe; Dawson 1956: 31, fig. 9
D. 13742a, growing in a mat of *Cladophora*.

Boodlea composita (Harvey) Brand; Taylor 1950: 44; Dawson 1954: 390, fig. 9c, d; Dawson 1956: 30
D. 13764, 13777, 13810, 13854, 13873, 13944, 14031. P. 2840, Eneroul Is. seaward tide flats, 9/23/54.

Boodlea siamensis Reinbold 1901: 107 (Thailand); Taylor 1950: 44
T. 46–400. Not collected again.

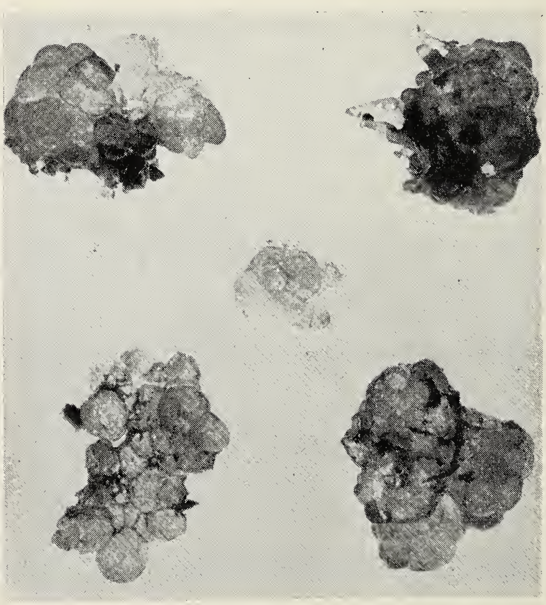


FIG. 3. *Dictyosphaeria intermedia*: Several fresh specimens of D. 13719, × 1.6.

Struvea anastomosans (Harvey) Piccone; Dawson 1954: 390, fig. 8g; Dawson 1956: 30
D. 13650, 13669, 13863, 13989, 14010.

Rhipidiphyllon reticulatum Askenasy; Dawson 1956: 32, fig. 10; Taylor 1950: 45
D. 13778, 14035a.

Microdictyon okamurai Setchell; Taylor 1950: 46, pl. 27, fig. 1; Dawson 1956: 32, fig. 11a
D. 13762, 13945. P. 54–18, Aitsu Is. seaward reef rim, 3/10/54; P. 2844, Bogombogo Is. seaward tide flats, 10/5/54.

Microdictyon japonicum is reported by Palumbo (1950) from Eniwetok without locality, based upon a determination by Lois Eubank Egerod.

Anadyomene wrightii Gray; Dawson 1954: 390, fig. 9e; Dawson 1956: 31
D. 13740.

Chaetomorpha indica Kützing; Dawson 1954: 386, fig. 6f, g; Dawson 1956: 33
D. 13982. P. 2842, Eneroul Is. seaward flats, 9/23/54; P. 2848, Bokanjoio Is. seaward flats, 9/29/54. These are apparently of the same entangled, free form found at Majuro Atoll without holdfast cells.

Rhizoclonium implexum (Dillwyn) Kützing 1845: 206; Smith 1944: 62, pl. 8, fig. 3. *Conferva implexa* Dillwyn 1809: 46, pl. B (England)

Fig. 4*a*

D. 13835, 14049a. This species is treated by Hamel under his genus *Lola*.

Cladophora crystallina (Roth) Kützing; Dawson 1956: 33, fig. 13b, c
D. 13923. The branches in this material range from 85 to 30 μ or less in diameter.

Cladophora inserta Dickie, variations; Dawson 1954: 388, fig. 7d (as *C. inserta* var. *ungulata*)

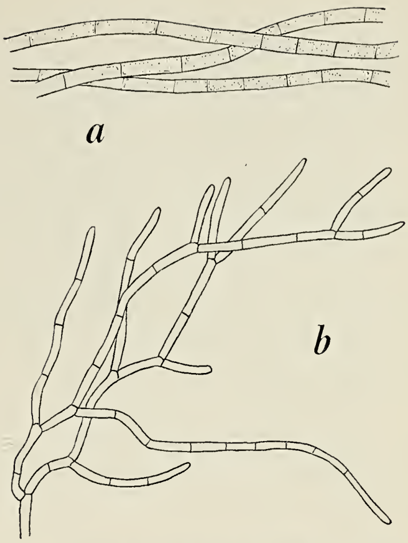


FIG. 4. *a*, *Rhizoclonium implexum*: Parts of filaments, × 80. *b*, *Cladophora socialis:* Part of a plant of D. 13742 near the typical form of the species, × 17.

D. 13837, 13857, 13903b. P. 2813, Bokanjoio Is. lagoon on stake in 3–8 ft., 3/8/55. Some of these specimens apparently correspond with var. *ungulata* (Brand) Setchell.

Cladophora socialis Kützing; Dawson 1956: 34; Dawson 1954: 388, fig. 7e (as *C. patentiramea* var. *longiarticulata* Reinbold)

Fig. 4*b*

D. 13699, 13742, 13806. These specimens seem to represent the same species collected by the writer in Viêt Nam and at Jaluit Atoll in the Marshall Islands. D. 13699 agrees especially well with Børgesen's Mauritius plant called *C. patentiramea* in 1940.

Cladophora luteola Harvey is reported by Palumbo (1950) from Eniwetok based upon a determination by F. Drouet, but a specimen so named by him from Bikini Atoll seems to be *Boodlea*.

Entocladia viridis Reinke; Dawson 1954: 388, fig. 7i
D. 13835a, in the cell wall of *Rhizoclonium*.

Derbesia attenuata Dawson 1954: 390, fig. 9a, b; Dawson 1956: 34
D. 13999b, epiphytic on *Halimeda;* D. 13767a, on small algae.

Derbesia marina (Lyngbye) Solier; Dawson 1956: 34, fig. 15a, b
D. 14006a, epiphytic on *Caulerpa.*

Derbesia ryukiuensis Yamada and Tanaka; Dawson 1956: 34, fig. 14b
D. 13710, 13791.

Bryopsis indica A. and Ethel Gepp; Dawson 1956: 34, fig. 14a; Taylor 1950: 50
D. 13730.

Bryopsis hypnoides Lamouroux 1809: 135, pl. 5, fig. 2 (Mediterranean Sea); Hamel 1931: 394, fig. 20 B; Smith 1944: 73, pl. 9, fig. 2

Fig. 5*a*, *b*

D. 13977.

Bryopsis pennata Lamouroux; Taylor 1950: 51; Dawson 1954: 393, fig. 11b; Dawson 1956: 34
D. 13703, 13797, 13859, 13907. P. 2855, Bogallua Is. lagoon pavement, 11/17/54. Considerable variation in branching occurs between examples corresponding to the type of the species and those better referred to the following variety.

Bryopsis pennata var. *secunda* (Harvey) Collins and Hervey 1917: 62; Taylor 1950: 52. *Bryopsis plumosa* var. *secunda* Harvey 1858: 31, pl. 45A, figs. 1–3 (Key West, Florida)
P. 52–31, Aomon Is. seaward reef, 10/22/52; P. 52–110, Engebi Is. lagoon, 11/8/52; P. 2585, Aitsu Is. 2/11/55; P. 2851, Bogombogo Is. seaward flats, 10/5/54; P. 2857, Aitsu Is. lagoon, 11/17/54.

Caulerpa acuta (Yamada) Yamada 1944: 34. *Caulerpa filicoides* Yamada 1936: 135, pl. 30, fig. 2. *Caulerpa verticillata* f. *acuta* Yamada 1934: 63, fig. 32 (Naha, Ryukyu Archipelago)

Figs. 6, 7

D. 13875, 13971, 14050.

Caulerpa antoensis Yamada; Dawson 1956: 36, fig. 20; Taylor 1950: 55, pl. 28, fig. 2 (as *C. arenicola* Taylor)
D. 13832.

Caulerpa bikiniensis Taylor 1950: 66, pl. 33 (Bikini Atoll, Marshall Is.)
D. 13774. The material is rather small and incompletely developed, but is apparently identical with Taylor's Bikini and Rogelap specimens. The problem of its relationship and possible varietal status in the *Caulerpa racemosa* complex cannot be taken up here.

Caulerpa brachypus Harvey 1859: 332 (Japan); Taylor 1950: 56, pl. 29, fig. 2
T. 46–422. Not collected again.

FIG. 5. *Bryopsis hypnoides*: *a*, Habit of part of a plant of D. 13977, × 5; *b*, detail of branching of the same, × 45.

Fig. 6. *Caulerpa acuta*: A small part of a blade of D. 13875 to show ultimate branching, × 100.

Caulerpa elongata f. *disticha* Taylor 1950: 55, pl. 52, fig. 1; Dawson 1956: 37 (as *C. elongata*)

D. 13723. *Caulerpa elongata* is supposed to be distinguished from similar forms of *C. webbiana* by its more lax and erect habit and absence of the abundant ramified filaments from the stolons. However, this specific distinction needs study. Taylor's plant is probably the same as that treated as *C. webbiana* f. *elegans* by Yamada and Tanaka 1938: 62, fig. 4.

Fig. 7. *Caulerpa acuta*: A dry specimen of D. 13875, × 1.2.

Fig. 8. *a*, *Caulerpa webbiana*: Upper part of a plant of D. 13679, × 22. *b*, *Caulerpa webbiana* f. *disticha*: Upper part of a plant of D. 13892, × 22.

Caulerpa webbiana Montagne 1838: 129, pl. 6 (Canary Islands); Eubank 1946: 415

Fig. 8*a*

D. 13679, 13807. P. 13, Igurin Is. seaward reef, 8/9/49.

Caulerpa webbiana var. *disticha* Weber van Bosse 1898: 270, pl. 21, fig. 1a–c (type locality not indicated)

Fig. 8*b*

D. 13626, 13850, 13864, 13892.

Caulerpa serrulata var. *serrulata* (Forskål) J. Agardh; Taylor 1950: 57, pl. 29, fig. 1, pl. 30, fig. 1; Dawson 1954: 393, fig. 10a; Dawson 1956: 38, fig. 23

D. 13952, 14047. P. 1225B, Parry Is. lagoon in 6 ft., 4/19/54.

Caulerpa racemosa var. *laetevirens* (Montagne) Weber van Bosse 1898: 366, pl. 33, figs. 8, 16–22; Taylor 1950: 64. *Caulerpa laetevirens* Montagne 1845: 16 (Toud Island)

Fig. 9*a*

D. 13628.

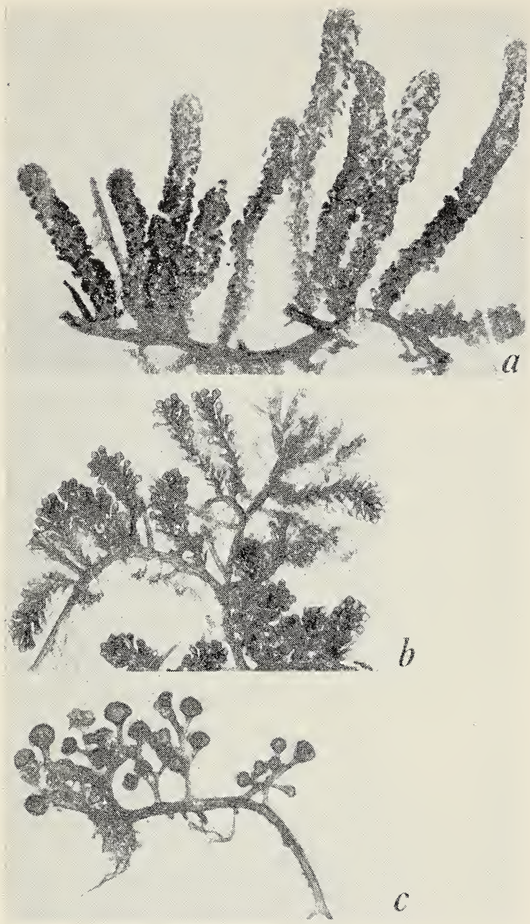


FIG. 9. *a*, *Caulerpa racemosa* var. *laetevirens*: Upper part of a plant of D. 13628, × 0.38. *b*, *C. racemosa* var. *laetevirens* f. *compressa*: Part of a plant of D. 13743, × 0.43. *c*, *C. racemosa* var. *clavifera*: A dry specimen of P. 12, × 0.75.

Caulerpa racemosa var. *laetevirens* f. *compressa* Taylor 1950: 64 (Eniwetok Atoll, Marshall Is.)

Fig. 9*b*

D. 13743, 13812.

Caulerpa racemosa var. *clavifera* (Turner) Weber van Bosse 1898: 361, pl. 33, figs. 1–5; Taylor 1950: 62. *Fucus clavifer* Turner 1808: 126, pl. 57 (Red Sea)

Fig. 9*c*

P. 12, Japtan Is. seaward reef, 8/8/49.

Caulerpa racemosa var. *peltata* (Lamouroux) Eubank; Dawson 1956: 35, fig. 16b; Taylor 1950: 65 (as *Caulerpa peltata* Lamx.)

D. 13735, 13793. The former have peltate foliar ramelli with dentate margins.

Caulerpa racemosa var. *peltata* f. *nummularia* (Harvey ex J. Agardh) comb. nov. *Caulerpa nummularia* J. Agardh 1872: 38 (Friendly Islands,-Tonga) *Caulerpa peltata* var. *nummularia* (J. Agardh) Weber van Bosse 1898: 376

Fig. 10

D. 13612, 13809. P. 2806, Parry Is. seaward reef, 3/6/55.

FIG. 10. *Caulerpa racemosa* var. *peltata* f. *nummularia*: Part of a plant of D. 13616b, × 4.5.

Caulerpa racemosa var. *macrophysa* (Kützing) Taylor; Dawson 1954: 393, fig. 10c; Dawson 1956: 35; Taylor 1950: 63

D. 13820. P. 1225, Parry Is. lagoon in 6 ft., 4/19/54.

Caulerpa racemosa (Forskål) J. Agardh near var. *uvifera* (Turner) Weber van Bosse 1898: 362, pl. 33, figs. 6, 7, 23; Taylor 1950: 63. *Fucus uvifer* Turner 1819: 81, pl. 230 (Red Sea)

D. 13635, 14006.

Caulerpa taxifolia (Vahl) C. Agardh; Dawson 1956: 35, fig. 17

D. 14046.

Caulerpa urvilliana Montagne; Taylor 1950: 60, pl. 31, figs. 1, 2, pl. 32, fig. 1; Dawson 1956: 37, fig. 21

D. 13607, 13632, 13674, 13757, 13818, 13845, 13862. P. 2824, Runo Is. seaward reef, 3/8/55; P. 2819, Bokanjoio Is. seaward reef, 3/8/55; P. 1225A, Parry Is. lagoon in 6 ft., 4/19/54. These specimens are variable, but for the most part approach the f. *tristicha* (J. Agardh) Weber van Bosse of the type variety of the species.

Caulerpa vickersiae Børgesen; Dawson 1956: 36, fig. 18; Dawson 1954: 392, fig. 9f (as *C. ambigua* Okam.)

D. 13617a, 13988a.

Codium arabicum Kützing; Dawson 1956: 38, fig. 24

D. 13947, 14004. P. 1220, Bogombogo Is. seaward flats, 4/15/54; P. 2831, off Igurin Is. in lagoon at 50 ft., 3/16/55.

Codium geppii O. C. Schmidt; Dawson 1954: 395, fig. 13 k; Dawson 1956: 39, fig. 26

D. 13722, 13951, 13926, 14003. P. 2593, Bogallua Is. lagoon, 2/11/55; P. 52–25, Aomon Is., 10/22/52.

Dr. Silva, in a personal communication, states that reef material of this plant collected by A. Conger and examined by him certainly belongs to the *C. geppii* complex, but is referable to *C. bulbopilum* Setchell, which he is about to decide to recognize in his monograph on *Codium*.

Codium edule Silva, mentioned by Odum and Odum (1955), has not been examined, but may be referable here.

Codium saccatum Okamura 1915: 145, pl. 135, figs. 1–5 (Futaye, Amakusa Island, Japan)

Fig. 11*a*

P. 2835, Bogombogo Is. on coral of tidal flats, 5/30/54. This plant agrees in size and shape and in the morphology of the utricles except for a slight development of alvaeolae in the utricle end-walls, not shown by Okamura for the type.

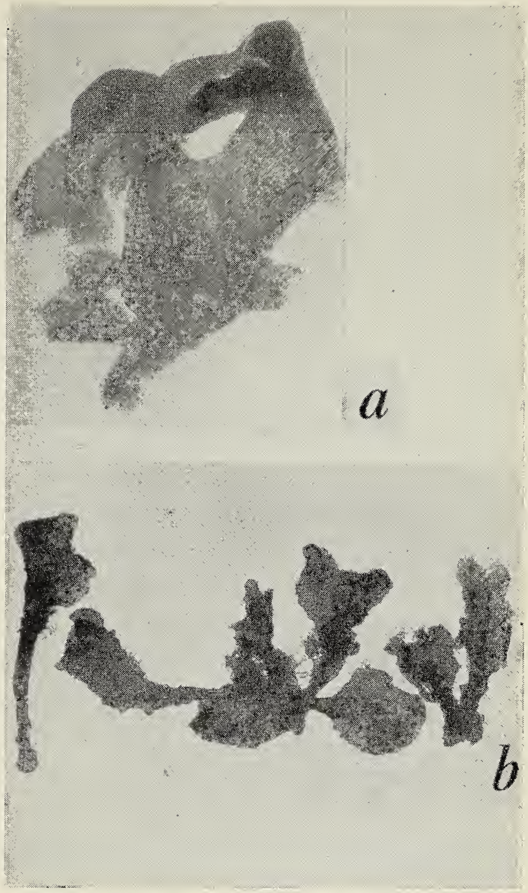


FIG. 11. *a*, *Codium saccatum*: A somewhat damaged plant of P. 2835, × 0.8. *b*, *Avrainvillea lacerata*: Habit of plants of D. 13629, × 1.05.

Codium tenue (Kützing) Kützing 1856, Tab. Phyc. 6: 33, pl. 95, fig. 1; Taylor 1950: 94. *Codium tomentosum* var. *tenue* Kützing 1849: 501 (Cape of Good Hope)

T. 46–436. Not collected again. Dr. Silva has reëxamined some preserved material of this collection and states in a personal communication that he considers it an undescribed species.

Pseudochlorodesmis furcellata (Zanardini) Børgesen; Dawson 1954: 395, fig. 11c

D. 13704b, 13987, 14048.

Avrainvillea lacerata Harvey ex J. Agardh 1887: 54 (Friendly Islands,-Tonga); A. and Ethel Gepp 1911: 38, figs. 105–109; Taylor 1950:70

Fig. 11*b*

D. 13629.

Rhipilia geppii Taylor 1950: 70, pl. 35 (Bikini Atoll, Marshall Islands)

D. 13721, 13889. P. 13x, Aaraanbiru Is. seaward reef margin, 3/7/54.

Rhipilia diaphana Taylor 1950: 72, pl. 37 (Bikini Atoll, Marshall Islands)

T. 46–425. Not collected again.

Rhipilia orientalis A. and Ethel Gepp; Taylor 1950: 72, pl. 36, fig. 1; Dawson 1956: 40

D. 13761, 13877, 13888.

Udotea palmetta var. *marshallensis* var. nov. Dawson 1956: 40, fig. 28a, b, c (as *U. palmetta*); Taylor 1950: 74 (as *U. indica*, at least in part)

Like the type, but the blade filament appendages in a single row, simple, blunt-conical, not forked.

A typo differt in appendiculis filamentae laminae in serie simplici efurcatis obtusiconicis.

TYPE: Dawson 13727, Aniyaanii Island, seaward reef on the coralline ridge, August 22, 1955.

ADDITIONAL MATERIAL: Kwajalein Atoll. D. 12554; Majuro Atoll. Horwitz 9576, 9599c, 9340a, 9390e; Eniwetok Atoll. T. 46–386, D. 13829, D. 13634, D. 13894, P. 2588a, Bogallua Is. lagoon rock pavement, 2/11/55, P. 54–33, Mui Is. seaward reef, 3/11/54, P. 2581a, Aaraanbiru Is. s.w. tip in channel, 2/11/55.

This considerable number of specimens has been found to show such consistent minor differences in the form of the blade filament appendages from the Indian Ocean type that there appears to be ample justification for its recognition under a distinctive subspecific name. One of Taylor's Eniwetok specimens referred by him to *U. indica* has been examined and found to be identical with the other Marshall Islands material. Presumably, his Rongerik, Rongelap and Bikini specimens treated as *U. indica* are also of this same plant.

Udotea javensis (Montagne) A. and Ethel Gepp; Dawson 1954: 395, fig. 13b, c; Dawson 1956: 40; Taylor 1950: 73

D. 13694, 13787, 13949.

Tydemannia expeditionis Weber van Bosse; Dawson 1956: 41; Taylor 1950: 73, pl. 38, fig. 1

D. 13962, 13997.

Halimeda gigas Taylor 1950: 84, pl. 44, fig. 2 (Eniwetok Atoll)

D. 13948, 13968, 13996. P. 1996, ½ mile off Parry Is. in lagoon at 140 ft., 9/9/54; P. 1947, ¼ mi. off Parry Is. in lagoon at 135 ft., 9/4/54; P. 2625, Parry Is. lagoon at 100 ft., 3/14/55; P. 2688, 1½ mile off Rigili Is. in lagoon at 60 ft., 3/16/55.

Halimeda macrophysa Askenasy 1888: 14, pl. 4, figs. 1–4 (Matuku Is., South Pacific); Barton 1901: 17, pl. 2, figs. 15–18

Fig. 12

D. 13879, 13897.

Halimeda monile (Solander) Lamouroux; Taylor 1950: 92, pl. 50, fig. 1; Dawson 1956: 41

D. 13706, 13836, 13937, 13953, 13969. P. 2828, 1½ mi. off Igurin Is. in lagoon at 50 ft., 3/8/55; P. 1993, ½ mi. off Parry Is. in lagoon at 140 ft., 9/9/54; P. 2687, 1½ mi. off Rigili Is. in lagoon at 60 ft., 3/16/55; P. 2620, 1½ mi. off Aaraanbiru Is. in lagoon at 70 ft., 3/11/55.

Halimeda lacunalis Taylor 1950: 91, pl. 51 (Eniwetok Atoll)

P. 2814, Bokanjoio Is. in lagoon off s.e. end of island at 60 ft., 3/8/55.

Halimeda stuposa Taylor 1950: 90, pl. 43, fig. 1, pl. 49, pl. 50, fig. 2 (Rongelap Atoll, Marshall Islands); Dawson 1956: 41

P. 2807, Parry Is. seaward reef edge, 3/6/55; P. 1203, Eneroul Is. lagoon, 4/14/54; P. 52–23, Aomon Is. lagoon at 5 ft., 10/22/52; P. 2588, Bogallua Is. lagoon rock pavement, 2/11/55.

Halimeda fragilis Taylor 1950: 88, pl. 48, fig. 2; Dawson 1956: 41

T. 46–394. Not collected again.

Halimeda opuntia (Linnaeus) Lamouroux; Taylor 1950: 80, pl. 39, fig. 1; Dawson 1954: 395, fig. 12; 1956: 41

D. 13631, 13700, 13734, 13796. P. 2529, 2530, ¼ mi. off Aaraanbiru Is. in lagoon at 20 ft., 3/9/55.

Halimeda opuntia f. *hederacea* Barton 1901: 21, pl. 3, fig. 23 (East Indies); Taylor 1950: 81, pl. 40, fig. 1; Dawson 1956: 42

D. 13954, 13998. P. 1950, ¼ mi. off Parry Is. in lagoon at 135 ft., 9/4/54.

Halimeda opuntia f. *minima* Taylor 1950: 82, pl. 39, fig. 2 (Bikini Atoll, Marshall Islands)

D. 14001.

FIG. 12. *Halimeda macrophysa*: Habit of a plant of D. 13879, × 0.5.

Halimeda opuntia f. *triloba* (Decaisne) Barton 1901: 20, pl. 2, fig. 20; Taylor 1950: 81, pl. 40, fig. 2. *Halimeda triloba* Decaisne 1842: 90 (China Sea)

D. 14001a. P. 2618, 1 mi. off Aaraanbiru Is. in the lagoon at 70 ft., 3/11/55.

Halimeda taenicola Taylor 1950: 86, pl. 46, fig. 1; Dawson 1956: 42

D. 13759.

Halimeda tridens f. *lamourouxii* (J. Agardh) Weber van Bosse; Taylor 1950: 93. *Halimeda incrassata* var. *lamourouxii* J. Agardh 1887: 86 ("in mari Antillarum"); Barton 1901: 27, pl. 4, fig. 41

Fig. 13

D. 14044.

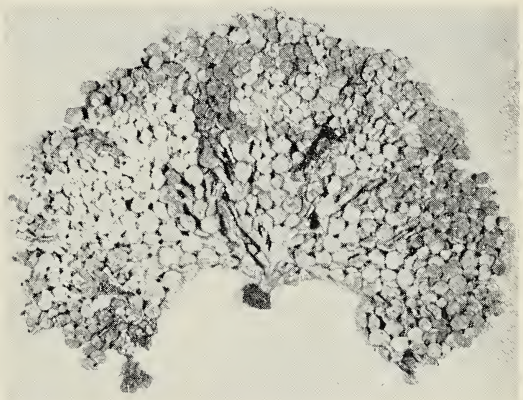


FIG. 13. *Halimeda tridens* f. *lamourouxii*: Habit of a plant of D. 14044, × 0.45.

Ostreobium reineckii Reinbold; Dawson 1954: 396, fig. 13g

D. 13776a, growing in the calcareous material of the lower side of *Peyssonelia rubra* var. *orientalis*.

Neomeris bilimbata Koster; Dawson 1956: 42, fig. 30a, b

D. 13772. Taylor's number 46–557 from Rongerik Atoll has been reëxamined and found to agree with this species rather than with *Neomeris vanbosseae* Howe.

Acetabularia moebii Solms-Laubach; Dawson 1954: 397, fig. 13j; Dawson 1956: 43
D. 13617b, 13660, 13858.

BROWN ALGAE

Ectocarpus breviarticulatus J. Agardh; Dawson 1954: 398, fig. 14a, b; Dawson 1956: 43
D. 13620, 14037. P. 2803, Bokanjoio Is. seaward reef margin, 10/25/54; P. 2804, Parry Is. seaward reef flats, 2/5/55.

Ectocarpus indicus Sonder, in Zollinger; Dawson 1956: 43, fig. 32; Taylor 1950: 95
D. 13766, epiphytic on *Turbinaria*, 13950, epiphytic on *Halimeda* and *Caulerpa*, 13959.

Ectocarpus irregularis Kützing; Dawson 1954: 398, fig. 14e, f; Børgesen 1941: 23, figs. 8–11
P. 2854a, epiphytic on *Dictyota*, Bogallua Is. lagoon pavement, 11/17/54.

Ectocarpus mitchellae Harvey; Taylor 1950: 95; Dawson 1954: 400, fig. 14c, d; Dawson 1956: 43; Børgesen 1941: 7, figs. 1–5
D. 13979.

Sphacelaria furcigera Kützing; Dawson 1954: 400, fig. 14h; Dawson 1956: 44
D. 13696a.

Sphacelaria novae-hollandiae G. Sonder; Dawson 1954: 400, fig. 14g; Taylor 1950: 97
D. 13748, 13768, 13936, all epiphytic on *Turbinaria*.

Sphacelaria tribuloides Meneghini; Dawson 1954: 400, fig. 14i, j; Dawson 1956: 44
D. 13622. P. 2812, Bokanjoio Is. lagoon on stake in 3 to 8 feet of water, 3/8/55.

Pocockiella papenfussii Taylor 1950: 98, pl. 54, fig. 2; Dawson 1956: 44
D. 13720. P. 54–31, Mui Is. seaward reef under rocks, 3/11/54.

Pocockiella variegata (Lamouroux) Papenfuss; Dawson 1954: 400, fig. 14k; Dawson 1956: 44
D. 13775, 13866.

Dictyota divaricata Lamouroux 1809: 331 (Mediterranean coast of France); Taylor 1928: pl. 16, figs. 6–9; Taylor 1950: 101

Fig. 14*a*

D. 13614 (juvenile), 13691, 13883, 13898. P. 2690, 1½ mi. off Rigili Is. at 60 ft., 3/16/55.

Dictyota patens J. Agardh; Dawson 1954: 401, fig. 16c
D. 13938. P. 2854, Bogallua Is. lagoon pavement, 11/17/54.

Dictyota pinnatifida Kützing 1859, Tab. Phyc. IX: 16, pl. 39 (Antigua, West Indies); Taylor 1950: 100
T. 46–416. Not collected again.

Dictyopteris repens (Okamura) Børgesen; Dawson 1956: 44, fig. 34
D. 13611, 13749.

Padina australis Hauck 1887: 44 (Cape York, North Australia); Weber van Bosse 1913: 179, fig. 52

Fig. 14*b*

D. 13678.

Padina commersonii Bory; Dawson 1954: 401, fig. 17; Taylor 1950: 100, pl. 54, fig. 1; Dawson 1956: 44
D. 13830, 14045. In this species the fertile zones alternate with hair zones, while in *P. australis* each fertile zone has a hair zone on either side separated from the next hair zone by a sterile zone.

Hydroclathrus clathratus (Bory) Howe; Dawson 1954: 403, fig. 18b; Taylor 1950: 96
D. 13918, 14021. P. 2845, Bokanjoio Is. seaward boat passage in 6 ft., 9/30/54.

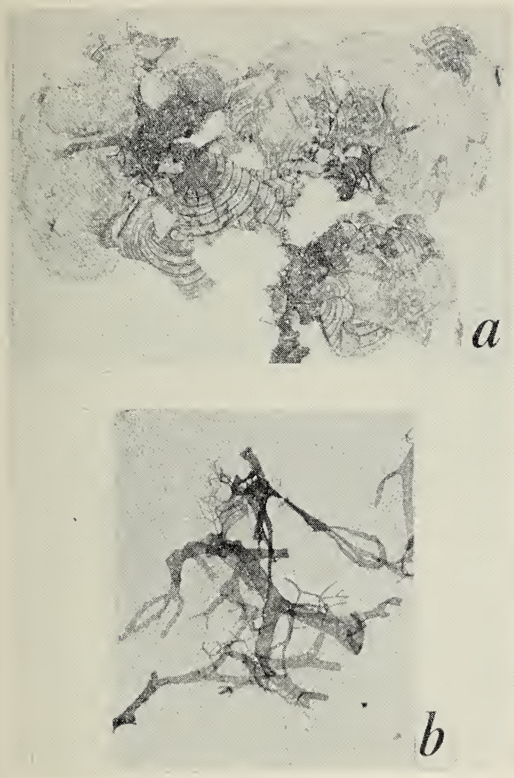


FIG. 14. *a*, *Padina australis*: Habit of a plant of D. 13678, × 0.8. *b*, *Dictyota divaricata*: Habit of parts of plants of D. 13691 showing great attenuation of some segments, × 0.7.

Rosenvingea intricata (J. Agardh) Børgesen 1914: 181; Taylor 1950: 97 *Asperococcus intricatus* J. Agardh 1847: 7 (Vera Cruz, Mexico)

Fig. 15

D. 13919. Rather dwarfish material which most closely resembles plants from the Gulf of California (Dawson 1944).

Rosenvingea fastigiata (Zanardini) Børgesen 1914: 26; Taylor 1950: 96, pl. 52, fig. 2. *Asperococcus fastigiatus* Zanardini 1872: 134, pl. 3, figs. 1–3 (Sarawak)
T. 46–332. Not collected again.

Chnoospora implexa Hering ex J. Agardh; Dawson 1954: 404, fig. 20a, b
D. 14022. P. 1195, Bokanjoio Is., seaward reef margin, 4/14/54.

Turbinaria ornata (Turner) J. Agardh; Dawson 1954: 405, fig. 21; Dawson 1956: 44; Taylor 1950: 100, pl. 53, fig. 2, pl. 55, fig. 2
D. 13693, 13765, 13802, 13935.

RED ALGAE

Goniotrichum elegans (Chauvin) Zanardini 1847: 69. *Bangia elegans* Chauvin 1842: 32 (Arromanches, France). Taylor 1950: 117 (as *G. alsidii* (Zanard.) Howe)

Fig. 16*a*, *b*

D. 13696e, epiphytic on a bit of *Cladophora* among other small algae in mixture.

Asterocytis ornata (C. Agardh) Hamel; Dawson 1954: 411, fig. 23a; Taylor 1950: 116
T. 46–427. Not detected again.

Erythrotrichia carnea (Dillwyn) J. Agardh; Dawson 1956: 45; Taylor 1950: 117; Tanaka 1952: 14, fig. 7B–E

Fig. 16*c*

D. 13906a.

Erythrotrichia parietalis Tanaka; Dawson 1954: 412, fig. 23d, e
D. 13696c.

Acrochaetium gracile Børgesen; Dawson 1954: 414, fig. 25h, i

Fig. 17*b*

D. 13696b, epiphytic on *Lophosiphonia* and

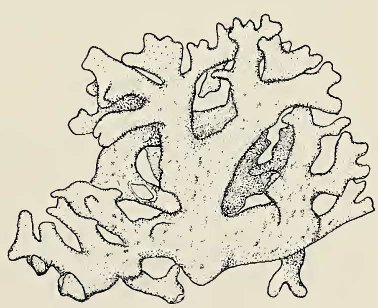


FIG. 15. *Rosenvingea intricata*: Habit of part of a small plant of D. 13919, × 3.7.

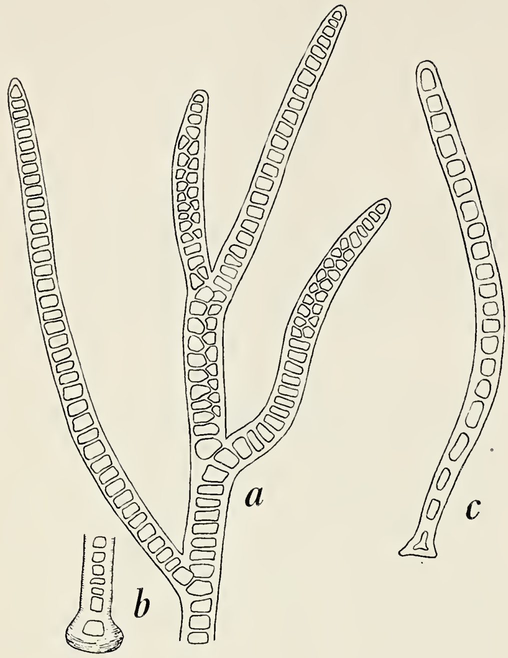


FIG. 16. *a*, *b*, *Goniotrichum elegans*: *a*, Habit of the upper part of a plant; *b*, basal part of same, both × 150 (after Børgesen). *c*, *Erythrotrichia carnea*: Habit of a young plant, × 300 (after Tanaka).

other small algae. This material seems to agree even better with the original account than the Viêt Nam specimens cited above. Attenuated hairs are common.

Acrochaetium robustum Børgesen; Dawson 1954: 414, fig. 25j, k
P. 2847, Bokanjoio Is. lagoon on *Enteromorpha*, 9/29/54.

Kylinia crassipes (Børgesen) Kylin 1944: 13. *Acrochaetium crassipes* Børgesen 1915: 20, figs. 11–13 (Virgin Islands)

Fig. 17*a*

D. 13620b, epiphytic on small algae.

Kylinia secundata (Lyngbye) Papenfuss 1947: 437. *Callithamnion daviesii* var. *secundatum* Lyngbye 1819: 129 (Denmark)

Fig. 17*c*, *d*

D. 13976b. Rather scant material, but fertile and in general agreement with the species as interpreted by the writer in 1953.

Liagora farinosa Lamouroux; Dawson 1954: 415, figs. 25d, 26; Taylor 1950: 119
P. 2820, Bokanjoio Is. seaward reef edge, 3/8/55.

Liagora hawaiiana Butters 1911: 164, pl. 24, figs. 8, 9 (Laie Bay, Oahu, Hawaiian Islands); Taylor 1950: 119, pl. 57, fig. 1; Abbott 1945: 151, fig. 3
D. 13828.

Liagora orientalis J. Agardh; Dawson 1954: 415, fig. 27b

Fig. 19*a*, *b*

A. Conger 4/27/51, Lidilibut Is., among coral heads in sandy channels on the ocean side. Principal specimen in the Bishop Museum. The material is sterile and is not positively identified.

Liagora pinnata Harvey 1853: 138, pl. 31 B, figs. 1–5 (Sand Key, Florida); Abbott 1945: 168

Fig. 18

P. 54–19, Aitsu Is., seaward reef near edge, 3/10/54.

Liagora robusta Yamada 1938: 8, pl. 12, fig. 1, text figs. 3, 4 (Ogasawara Islands)

Fig. 19*c*, *d*

A. Conger 4/27/51, Lidilibut Is. in sandy channels on the ocean reef side. Sterile and not positively identified.

Asparagopsis taxiformis (Delile) Collins and Hervey 1917: 117. *Fucus taxiformis* Delile 1813: 295, pl. 57, fig. 2 (Alexandria, Egypt)

Fig. 20

D. 13627, 13843, 14018. P. 16, Japtan Is. seaward reef, 8/8/49; P. 2601a, Rigili Is., 2/11/55; P. 2501, Engebi Is. lagoon at n.w. tip in 15 ft., 3/2/55.

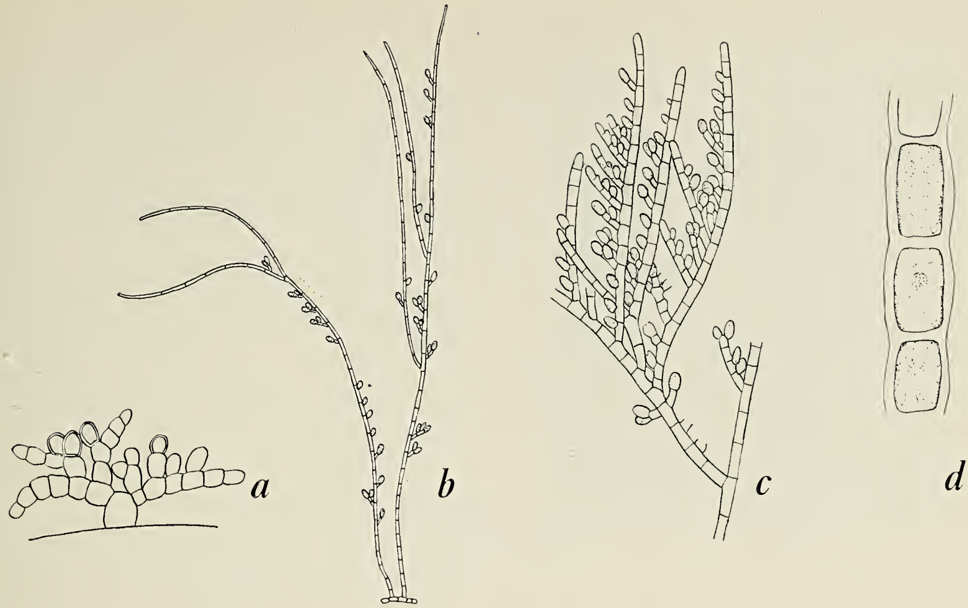


FIG. 17. *a*, *Kylinia crassipes*: Habit of a plant, × 290. *b*, *Acrochaetium gracile*: Habit of part of a plant, × 150 (after Børgesen). *c*, *d*, *Kylinia secundata*: *c*, Habit of the upper part of a plant, × 160; *d*, detail of stellate chromatophores in part of a filament, × 1000 (after Dawson).

Falkenbergia hillebrandii (Bornet) Falkenberg = sporophyte generation of *Asparagopsis taxiformis* (Delile) Collins and Hervey; Dawson 1954: 414, fig. 25l; Dawson 1956: 45

D. 13623, 13913, 14018a. P. 2836b, Parry Is. seaward reef edge, 4/4/54.

Galaxaura fastigiata Decaisne; Dawson 1954: 419, fig. 30b

P. 2805, Bogombogo Is. seaward reef flats, 2/9/55.

Galaxaura filamentosa Chou; Dawson 1954: 419, fig. 30a; Dawson 1956: 46

D. 14005. Rather scant, young material.

Gelidium crinale var. *perpusillum* Piccone and Grunow; Dawson 1954: 421, fig. 31e, f

D. 13798.

Gelidium pusillum (Stackhouse) Le Jolis, formas; Dawson 1954: 420, fig. 31a–c; Dawson 1956: 46

D. 13819, 13841.

Gelidiella bornetii (Weber van Bosse) Feldmann and Hamel 1934: 528; Børgesen 1938: 210, fig. 2a, b. *Gelidium bornetii* Weber van Bosse 1926: 107 (Kei Islands)

Fig. 21

D. 14035 is a good match for Børgesen's 1938 figure. The small size and compressed to flattened branches lacking rhizoidal filaments are distinctive.

Gelidiella tenuissima Feldmann and Hamel; Dawson 1954: 422, fig. 33e; Dawson 1956: 46

D. 13660a, 13908, 14032.

Gelidiopsis intricata (C. Agardh) Vickers; Dawson 1954: 423, fig. 34a–d; Dawson 1956: 46

D. 13903.

Wurdemannia miniata (Lamark and DeCandelle) Feldmann and Hamel: Dawson 1954: 424, fig. 35; Dawson 1956: 47

D. 13640b, 14036.

FIG. 18. *Liagora pinnata*: Habit of a dry specimen of P. 54–19, × 0.65.

Cruoriella dubyi (Crouan and Crouan) Schmitz; Dawson 1956: 47, fig. 39
D. 13856.

Peyssonelia rubra var. *orientalis* Weber van Bosse; Dawson 1954: 424, fig. 36c; Dawson 1956: 47; Taylor 1950: 121
D. 13776, 13991.

Porolithon craspedium (Foslie) Foslie 1909: 57; Taylor 1950: 126, pls. 64, 65. *Lithophyllum craspedium* Foslie 1900: 26 (Onatoa, Gilbert Islands)
D. 13717, 13943.

Porolithon oncodes (Heydrich) Foslie 1909: 57; Taylor 1950: 125, pls. 9, 61, 62, 63. *Lithophyllum oncodes* Heydrich 1897: 410 (Tami Island, New Guinea)
D. 13618, 13869, 14019.

Porolithon gardneri f. *subhemispherica* Foslie 1907: 190 (Indian Ocean); Taylor 1950: 129, pls. 5–9, 70, fig. 1; pls. 71–73, 76, fig. 2; pl. 77
T. 46–373, T. 46–306, T. 46–406. Not collected again since 1946.

Fosliella farinosa (Lamouroux) Howe; Dawson 1954: 425, fig. 37c; Taylor 1950: 132 (as *F. farinosa* var. *solmsiana* (Falkenb.) Taylor, prox.
D. 13720a, epiphytic on *Pocockiella*.

Heteroderma minutula Foslie; Dawson 1956: 47, fig. 40
D. 13719a, 13821, both epiphytic on *Dictyosphaeria intermedia*; D. 13994a, epiphytic on *Valonia*.

Heteroderma subtillissima Foslie; Dawson 1956: 48, fig. 41a, b
D. 13857b, in *Jania* turf; D. 13818, epiphytic on *Caulerpa urvilliana*.

Jania capillacea Harvey; Dawson 1954: 432, fig. 41a, b; Dawson 1956: 49; Taylor 1950: 133
D. 13640, 13649, 13692. P. 2858, Runit Is. in channel at n.w. tip, 4/11/54.

Jania decussato-dichotoma (Yendo) Yendo; Dawson 1956: 49, fig. 44
D. 13769, 13805, 13910. The specimens cited by Taylor 1950: 133 under *Jania rubens* Lamx. are presumed to correspond with this common Pacific species.

Jania micrarthrodia Lamouroux; Dawson 1956: 49, fig. 42; Taylor 1950: 134 (as *J. antennina* Kützing, prox.)
T. 46–345B. Not collected again.

Jania tenella Kützing; Dawson 1956: 49, fig. 43
P. 2836a, Parry Is. seaward reef edge, 4/4/54; P. 2860, same, 3/10/54.

Grateloupia filicina (Wulfen) C. Agardh; Dawson 1954: 432, fig. 42a
D. 13972. P. 2837, same locality, 5/29/54.

Hypnea esperi Bory; Dawson 1954: 436, fig. 46h–j; Dawson 1956: 51
D. 13617, 13697, 13788, 13852, 13814, 13902, 13939, 14015. Taylor's Eniwetok col-

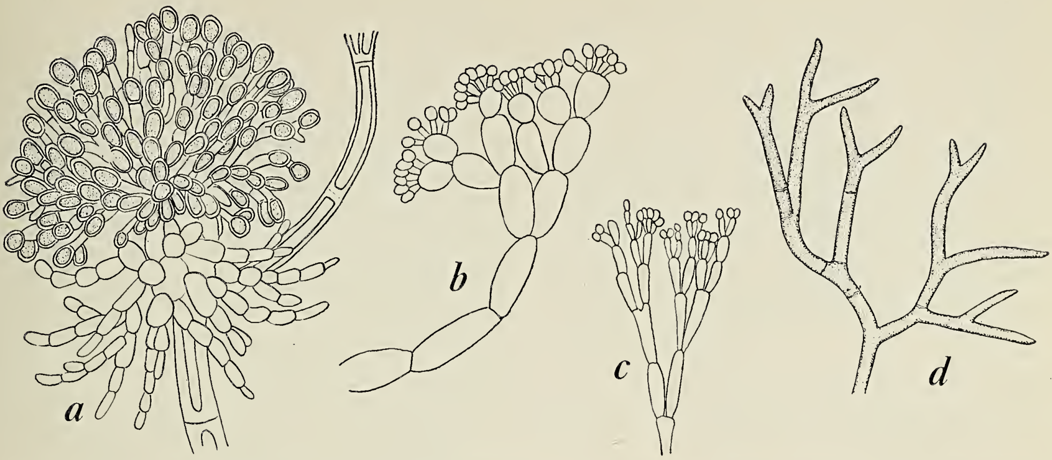


FIG. 19. *a, b, Liagora orientalis: a,* A young cystocarp, × 300; *b,* an antheridial branch, × 470 (both after Yamada). *c, d, Liagora robusta: a,* An antheridial branch, × 350 (after Yamada); *b,* part of a plant of Conger 4/27/51 showing the open dichotomous branching and annulations, × 1.5.

FIG. 20. *Asparagopsis taxiformis*: Habit of dry plants typical of the small reef form, × 1.15.

lection of *Hypnea* under no. 46–378 called *H. spinella* (Ag.) Kütz. is probably the same as these.

Hypnea nidulans Setchell; Dawson 1954: 438, fig. 46e–g
D. 13861.

Hypnea pannosa J. Agardh; Dawson 1956: 51, fig. 46
D. 13912.

Dicranema rosaliae Setchell and Gardner 1924: 745, pl. 22, fig. 6 (Gulf of California, Mexico)
Figs. 22*a;* 23*a*
D. 13980.

Botryocladia skottsbergii (Børgesen) Levring; Dawson 1956: 52, fig. 48; Taylor 1950: 135 (as *Botryocladia kuckuckii* Weber van Bosse) Yamada and Tanaka
D. 13986, 14033.

Coelothrix irregularis (Harvey) Børgesen 1915–20: 389, figs. 373, 374. *Cordylecladia ? irregularis* Harvey 1853: 156 (Key West, Florida)
Fig. 23*b*

D. 13782. The tetrasporic material agrees exactly with Harvey. It is probably identical also with *C. indica* Børgesen from Mauritius which seems doubtfully distinct in view of this Pacific record. The species is probably widespread in tropical waters but of infrequent occurrence in the Pacific and Indian Ocean regions.

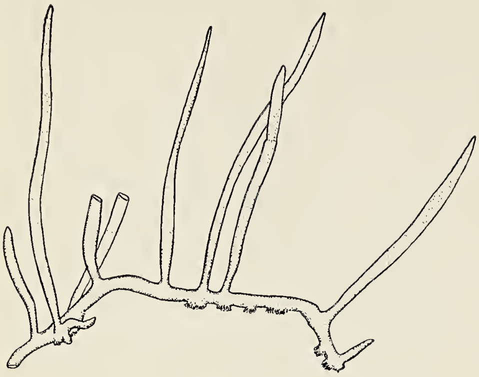


FIG. 21. *Gelidiella bornetii*: Habit of part of a plant of D. 14035, × 9.

Lomentaria hakodatensis Yendo; Dawson 1956: 52, fig. 50
D. 13709, 13853, 13928, 13999i, 14025.

Champia parvula (C. Agardh) Harvey; Dawson 1954: 443, fig. 52c; Dawson 1956: 51
D. 13746, 13849, 14015a.

Champia vieilardii Kützing ?; Dawson 1954: 443, figs. 52e, 53; Dawson 1956: 51
D. 13999f. A small fragment only of uncertain identity.

Rhodymenia anastomosans Weber van Bosse; Dawson 1956: 52, fig. 49
D. 13900.

Antithamnion lherminieri (Crouan and Crouan) Nasr; Dawson 1956: 53, fig. 51
D. 13609a, creeping among other minute algae; 13696b, 13950b, epiphytic on *Halimeda* and *Caulerpa;* 13999b, epiphytic on *Halimeda.*

Antithamnion percurrens sp. nov.

Fig. 24*a*, *b*

Thalli minute, densely tufted, 5–6 mm. high, uniseriate throughout; creeping, prostrate filaments of lower parts fastened to the calcareous substrate by short lateral branchlets modified for attachment; main axes both prostrate and erect about 15–18 μ in diameter, of cells mostly 2–3 diameters long; erect axes strongly percurrent, without indeterminate branches; determinate lateral branchlets regularly distichous from every axial cell, 60–120 μ long, symmetrically curved upward, commonly bearing 1–3 short, 1–2 celled secondary determinate branchlets on the adaxial side; all branch tips blunt; tetrasporangia about 20 μ in diameter, tripartite, sparse, sessile, borne within a large, prominent, gelatinous envelope from the adaxial side of the basalmost cell of a lateral branchlet, usually causing a local disarrangement of the pinnae because of the size of the envelope.

Thallis 5–6 mm. altis in omnis partibus uniseriatis, axilibus principalibus valde percurrentibus 15–18 μ diametro cellulis plerumque 2–3-plo longioribus quam latis,

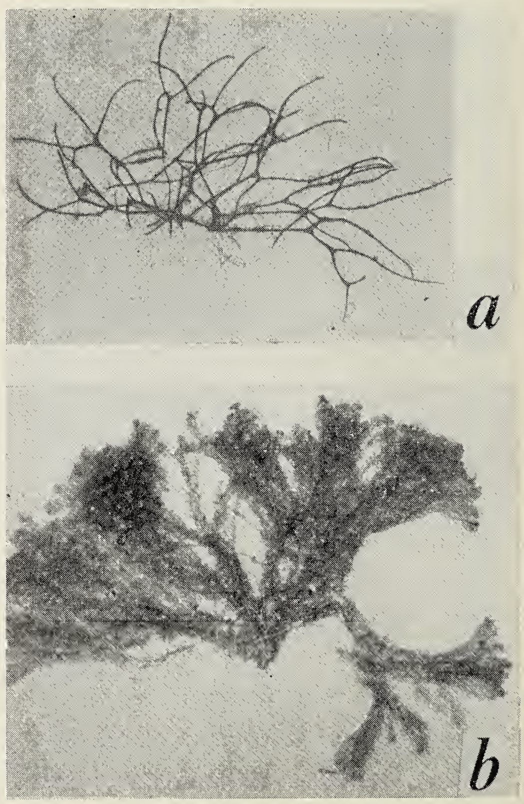


FIG. 22. *a*, *Dicranema rosaliae*: Habit of a dry plant of D. 13980, × 1.7. *b*, *Dasya iyengarii*: Habit of part of a dried tuft of a somewhat robust form, × 2.0.

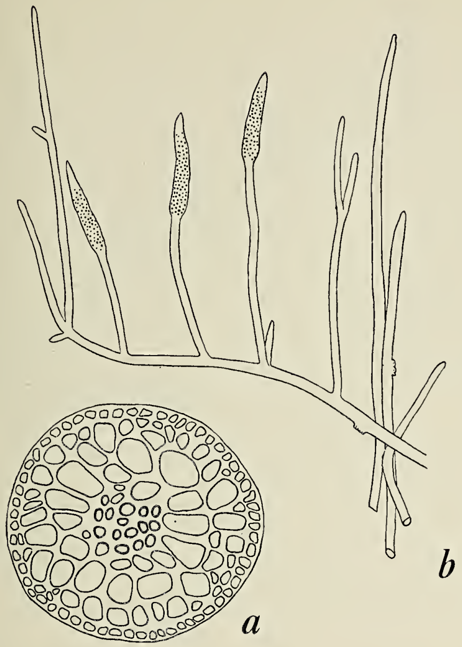


FIG. 23. *a*, *Dicranema rosaliae*: Transection of a branch to show central core of small cells (after Setchell and Gardner). *b*, *Coelothrix irregularis*: Habit of part of a tetrasporic plant of D. 13782 with stichidia, × 10.

ramulis lateralibus determinantibus regulariter distichis ex cellulis axilaribus omnibus salientibus 60–120 μ longis adscendenti-curvatis et in latere adaxilare ramulis determinantibus secundariis productis, apicibus ramorum obtusis, tetrasporangiis ca. 20 μ diametro tripartitis sessilibus sparsis e latere adaxiali cellulae inferioris ramulis lateralibus productis.

TYPE: Dawson 13633, forming tufts on crustose coralline algae near the outer margin of the seaward reef opposite EMBL, Parry Island, August 19, 1955.

This plant is related to *Antithamnion pteroton* Schousb. ex Bornet, but is a markedly distinct species in its percurrent erect axes, its large, sessile sporangia, and the short, symmetrical pinnae lacking any abaxial secondary branchlets.

Antithamnion breviramosus var. *simplex* var. nov.

Fig. 24*c*, *d*

Like the type, but more delicate and slender with main axes only 25–30 μ in diameter, and with lateral branchlets simple or only once forked; axial cells longer, 6–8 (10) diameters long; attachment by a short, 1–2 celled rhizoidal outgrowth from the lowermost cell of a lateral branch.

A typo simili sed axilibus principalibus tantum 25–30 μ diametro et cellulis longioribus 6–8 (10)-plo longioribus quam latis, ramulis lateralibus simplicibus vel unifurcatis.

TYPE: Dawson 13704a, creeping on *Griffithsia tenuis* from coral heads at a depth of 10 feet in the lagoon, south end of Parry Island, August 21.

This tiny plant is remarkably similar to that described from Santa Catalina Island, California (Dawson 1949: 14, figs. 28, 57) and seems to be only a more delicate, lax, and less-branched variant of that species.

Callithamnion marshallensis sp. nov.

Fig. 25*a–c*

Thalli attached to other algae or to shells or debris, loosely tufted, 4–5 mm. high, consisting of an irregularly semi-prostrate part attached by modified lateral branchlets with adherent terminal discs, some of the attachment branchlets distinctly catenate in their cell form and unlike vegetative branchlets; main axes 80–90 μ in diameter, non-corticated, of cells 1–1½ diameters long; lateral branchlets 20–30 μ in diameter, lax, long, somewhat attenuate but terminally blunt, mostly simple, curved, alternate, but not always from every cell, mostly spirally arranged, often with approximately ⅕ divergence, but sometimes in part tending to be distichous; tetrasporangia tripartite, subspherical, about 40 μ in diameter, sessile and

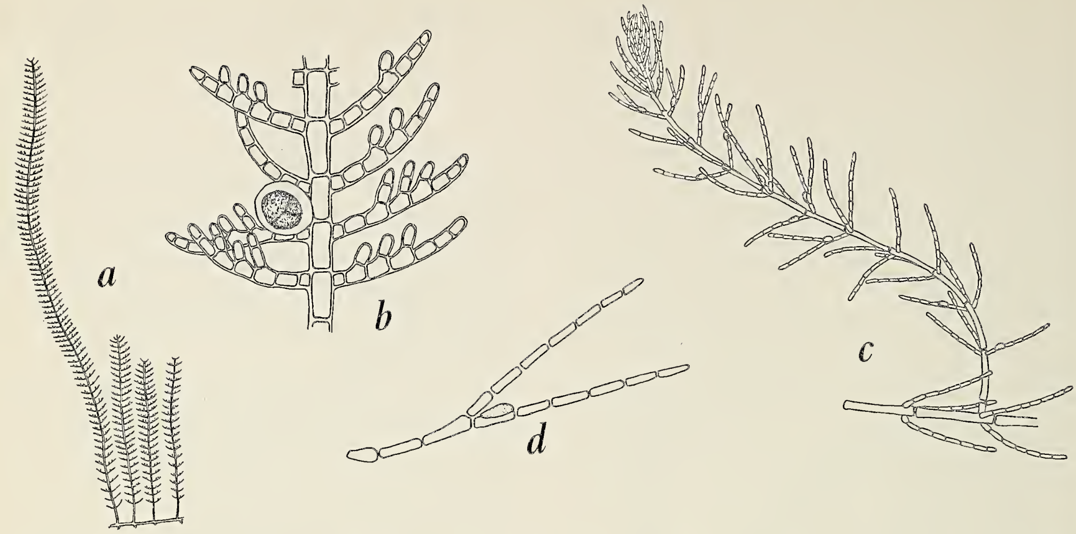


FIG. 24. *a*, *b*, *Antithamnion percurrens: a*, Habit of part of a plant of the type collection, × 13; *b*, part of a plant bearing a tetrasporangium, × 150. *c*, *d*, *Antithamnion breviramosus* var. *simplex: c*, Habit of part of a plant of the type collection, × 68; *d*, detail of an ultimate forked branch bearing a gland cell, × 300.

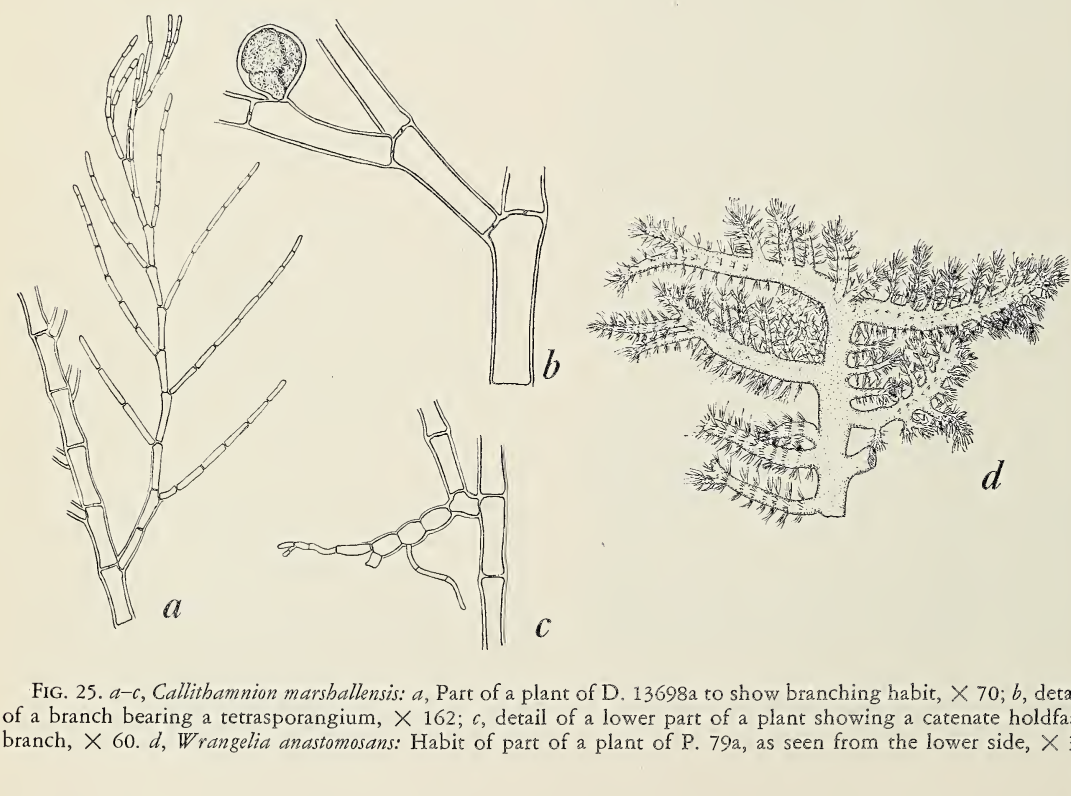


FIG. 25. *a–c*, *Callithamnion marshallensis: a*, Part of a plant of D. 13698a to show branching habit, × 70; *b*, detail of a branch bearing a tetrasporangium, × 162; *c*, detail of a lower part of a plant showing a catenate holdfast branch, × 60. *d*, *Wrangelia anastomosans:* Habit of part of a plant of P. 79a, as seen from the lower side, × 3.

adaxial, one or several in the lower half of a lateral branchlet in mid-parts of thallus.

Thallis 4–5 mm. altis, partibus inferis semiprostratis a ramulis lateralibus mutatis in discis adhaerentibus, axilis principalibus 80–90 μ diametro ecorticatis et cellulis 1–1½-plo longioribus quam latis, ramulis lateralibus 20–30 μ diametro laxis subattenuatis sed obtusis plerumque simplicibus curvatis alternatis plerumque contorte affixis, tetrasporangiis tripartitis ca. 40 μ diametro sessilibus adaxialibus in dimidia parte infera ramulae lateralis in media thalli affixis.

TYPE: Dawson 13695, on shells and dead coral from a depth of 6–10 feet in the lagoon, south end of Parry Island, Eniwetok Atoll, August 21.

ADDITIONAL MATERIAL: D. 13992, under rocks on reef along passage; D. 13950a, epiphytic on *Halimeda* and *Caulerpa*; D. 13997c, epiphytic on *Halimeda*; D. 13698a.

This species is seemingly nearest to *Callithamnion paschalis* Børgesen (1924: 294, fig. 35) from Easter Island, but is neither consistently distichously branched like that species nor with the tetrasporangia borne in the terminal branchlets of the main axes.

Wrangelia anastomosans Yamada 1944: 41, pl. 7, fig. 2 (Ant Atoll, Caroline Islands)

Fig. 25*d*

P. 79a, Igurin Is. tide flats in shallow water, 11/4/54.

Wrangelia argus (Montagne) Montagne; Dawson 1954: 444, fig. 54g; Dawson 1956: 56

D. 13941. This material agrees with the details by which Tseng (1942) differentiates *W. argus* from *W. tayloriana* Tseng, and lacks the more or less complete cortication of *W. penicillata*. The involucral filaments are about 11–13 μ in diameter, of 3 to 5 cells, often dichotomous and strongly curved. The tetrasporangia are 70–80 μ in diameter at maturity.

Wrangelia penicillata C. Agardh 1828: 138 (Adriatic Sea); Taylor 1950: 136

T. 46–336. Not collected again.

Griffithsia ovalis Harvey 1862, vol. 4: pl. 203 (King Georges Sound, West Australia); Abbott 1946: 440, pl. 1, figs. 1–4, pl. 2, figs. 1, 2

Fig. 26*a–d*

D. 14012, fertile. Several other sterile collections were made of a *Griffithsia* which is probably this species.

Griffithsia tenuis C. Agardh; Dawson 1954: 450, fig. 56e; Dawson 1956: 56

D. 13702, 13785, 13950d, 13956, 14029.

Neomonospora pedicellata var. *tenuis* Feldmann-Mazoyer; Dawson 1954: 450, fig. 56a

D. 13610a.

Ceramium clarionense Setchell and Gardner; Dawson 1954: 448, fig. 55k; Dawson 1956: 54

D. 13767. This material, epiphytic on *Turbinaria*, is sterile, but the circinate tips and

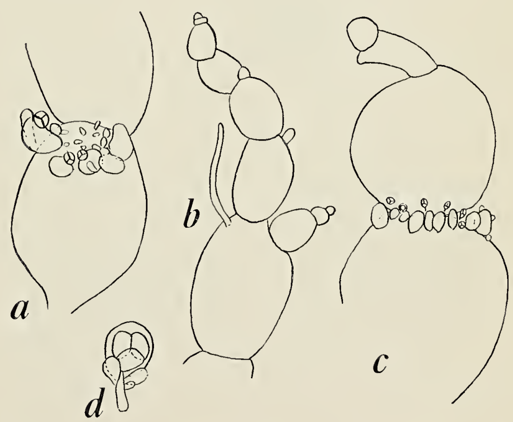


FIG. 26. *a–d*, *Griffithsia ovalis*: *a*, Vegetative cells with involucrate tetrasporangia between articulations, × 30; *b*, habit of part of a specimen with a rhizoid, × 16; *c*, involucrate tetrasporangia near the top of a plant, × 26; *d*, a mature tetrasporangium on a pedicel, × 300 (all after Abbott).

the peculiar exudation droplets from certain cortical cells seem to mark it clearly.

Ceramium marshallense sp. nov.

Fig. 27*a*, *b*

Thalli creeping and entangled among other algae in low turfs, 1 cm. or less in extent, consisting of creeping lower parts fastened to surrounding materials by numerous rhizoids, and free branches 4–5 mm. long; branching primarily dichotomous, with occasional irregular secondary branches; sterile apices strongly forcipate and usually circinately inrolled; main axes to 140–155 μ in diameter; cortication incomplete, consisting of nodal bands about 50–60 μ wide separating uncorticated internodal areas 40–70 μ wide; cortical bands consisting of a central ring of larger, isodiametrical cells about 22–30 μ in diameter and on either side, or somewhat overlapping, an irregular single to double ring of smaller angular cells 10–17 μ in greatest diameter; fertile, outer, erect parts of tetrasporangial plants somewhat catenately swollen, 160–185 μ in diameter; tetrasporangia mostly completely immersed beneath the tumid cortex, 35–40 μ in diameter, whorled after an initial tendency to be abaxial; sexual reproduction unknown.

Thallis repentibus et implicatis ad 1 cm. longis a rhizoideis multis affixis, ramis solutis 4–5 mm. longis, ramulis plerumque dichotomis, apicibus circinatis, axilibus principalibus 140–155 μ diametro, cortice interrupta, vittis corticalibus noduloris ca. 50–60 μ latis

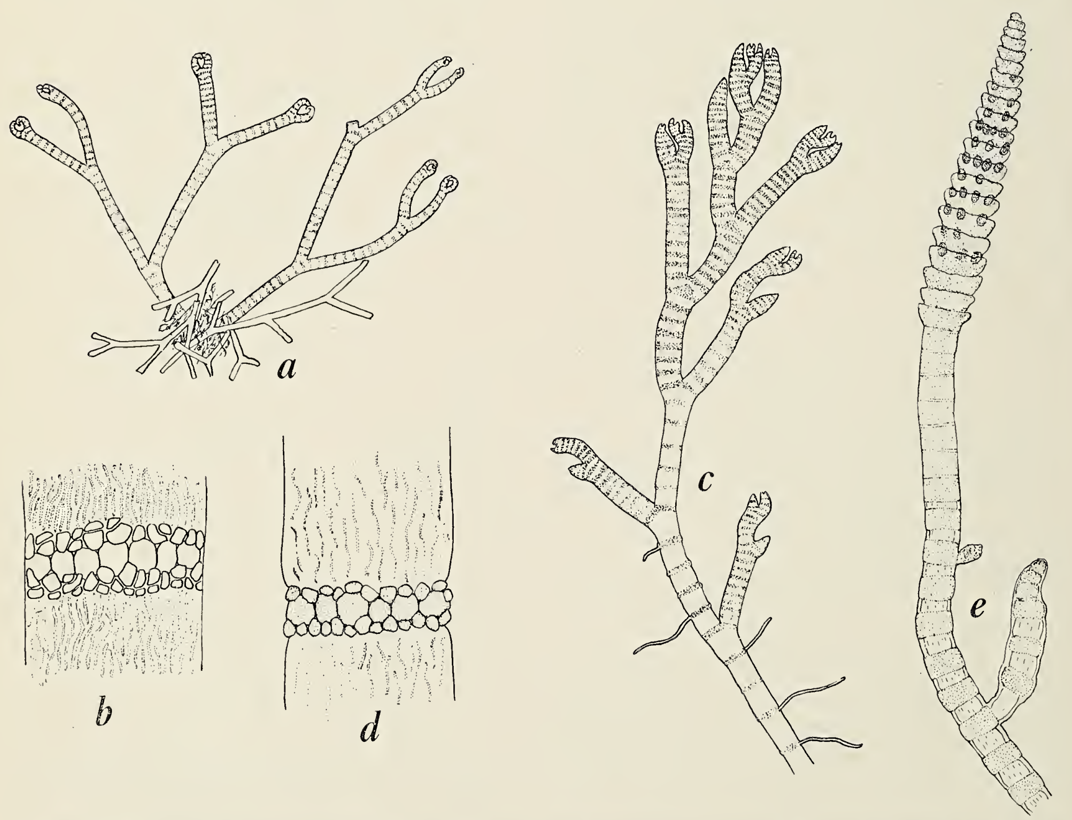


FIG. 27. *a*, *b*, *Ceramium marshallense: a*, Habit of a plant of the type collection, × 12; *b*, detail of a node of the same, × 150. *c*, *d*, *Ceramium sympodiale: c*, Habit of a plant of the type collection, × 26; *d*, detail of a node of the same, × 150. *e*, *Ceramium vagabunde:* Habit of the upper part of a tetrasporangial plant of the type collection, × 34.

a circulo unico cellulis majoribus 22–30 μ diametro et in lateribus ambis circulo irregulari cellulis minoribus angulosis 10–17 μ diametro, internodis 40–70 μ latis, tetrasporangiis 35–40 μ diametro verticillatis plerumque tota immersis sub cortice tumidi.

TYPE: Dawson 14013, growing in a *Jania* turf among rocks near the northern seaward reef edge of Rigili Island, Sept. 2.

This species is distinct in its small size, circinate apices, narrow cortical bands less than one-half as tall as broad, and in its immersed, whorled tetrasporangia. It approaches *C. mazatlanense* Dawson, but differs in the cellular arrangement of the cortical bands and in the whorled, immersed tetrasporangia.

Ceramium sympodiale sp. nov.

Fig. 27*c*, *d*

Thalli 1 cm. or less in height or extent, with main axes 110–130 μ in diameter, consisting of repent or entangled lower parts growing amid other small algae in tufts or turfs, attached at many places by rhizoids from the nodes, giving rise to erect, free parts 3–4 mm. high; branching sympodial and essentially distichous, the branches approximate above and becoming more widely spaced below by elongation of the internodes; branches at extreme apices at first more or less corymbose and the tips slightly forcipate with clearly visible apical cells; cortication incomplete, in narrow bands 35–40 μ wide (⅓ the diameter of the axis or less), consisting of a single ring of larger cells about 30–35 μ in diameter with smaller, angular cells on either side; internodes very narrow in upper parts, about 10 μ wide, expanding below to as much as 170 μ; reproduction not seen.

Thallis ad 1 cm. latis, axilibus principalibus 110–130 μ diametro, partibus inferis repentibus a rhizoideis noduloris affixis, partibus solutis 3–4 mm. altis, ramis sympodialibus et plerumque distichis ad apices corymbosis, apicibus subforcipatis, cortice interrupti vittis corticosis nodi 35–40 μ latis a circulo unico cellulis majoribus 30–35 μ diametro et in lateribus ambis cellulis minoribus anguloris, inter nodis supra angustioribus ca. 10 μ latis infra latioribus ad 170 μ latis.

TYPE: Dawson 14014, in clumps of other small algae under coral rocks near the northern edge of the seaward reef of Rigili Island, September 2.

The sympodial, distichous branching and very narrow cortical bands are distinctive in this small species despite the absence of fertile material.

Ceramium vagabunde sp. nov.

Fig. 27*e*

Plants minute, 4–5 mm. high, growing among other tufted algae, consisting of a creeping, semi-prostrate basal filament provided with numerous ventral rhizoids from the nodes, giving rise to irregularly and sparsely branched erect branches with blunt, non-forcipate tips; erect axes 120–140 μ in diameter, incompletely corticated, the internodes bare for intervals of 30–70 μ in middle and lower parts; cortical bands 1½–2 times as broad as tall, without secondary growth above or below, the margins even, especially the lower ones, consisting of a narrow inner ring of larger cells and on either side of an outer ring of irregularly arranged small angular cells less than 10 μ in maximum diameter; tetrasporangia cruciate, ovate, about 40 μ in length, borne verticillately within prominently swollen involucres which develop acropetally from the closely juxtaposed distal nodal bands of the erect axes; terminal fertile areas to 220–250 μ in diameter, resembling those of *Equisetum* in form.

Thallis 4–5 mm. altis e filamentis basilaribus repentibus a rhizoideis nodularibus affixis et ramis sparsis irregularibus erectis apicibus obtusis eforcipatis, axilaribus erectis 120–140 μ diametro, cortice interrupto, vittis corticosis nodi 1½–2-plo latioribus quam longis a circulo angusto centrali cellulis majoribus et

lateribus ambis corio cellulis minoribus anguloris ad 10 μ diametro, tetrasporangiis cruciatis ovatis ca. 40 μ longis in involucris valde inflatis eis ex vittis nodoris proxime juxtaposis axilarum erectarum acropetaliter productis, loculis fertilibus terminalibus 220–250 μ diametro eis *Equisetum* similantibus.

TYPE: Dawson 13620a, growing within tufts of *Ectocarpus breviarticulatus* near the margin of the seaward reef opposite EMBL, Parry Island, August 19.

This material is nearest to *Ceramium nakamurai* Dawson from Garanbi, Formosa (*C. equisetoides* Nakamura), but is not dichotomously branched. It is identical with tetrasporangial specimens cited and illustrated by the writer as a probable undescribed species from Isla San Benedicto, Mexico (Dawson 1954a: 6, pl. 4, fig. 2).

Ceramium gracillimum var. *byssoideum* (Harvey) G. Mazoyer; Dawson 1954: 448, fig. 55e, f; Dawson 1956: 53; Taylor 1950: 138 (as *Ceramium byssoideum* Harvey)

D. 13616, 13707, 13715, 13790, 13831, 13860, 13891, 13924, 13916, 13951, 14028.

Ceramium mazatlanense Dawson; Dawson 1954: 448, fig. 55g–j; Dawson 1956: 53

D. 13752, epiphytic on *Caulerpa*.

Ceramium serpens Setchell and Gardner ?; Dawson 1956: 54, fig. 53

D. 13610b, 13857. Both are sterile and not positively identified.

Ceramium taylori Dawson; Dawson 1954: 446, fig. 55b, c

D. 13637, epiphytic on *Udotea*, 13817, 13942.

Centroceras apiculatum Yamada; Dawson 1956: 55, fig. 55

D. 13941a, 14016.

Centroceras clavulatum (C. Agardh) Montagne; Dawson 1954: 446, fig. 54b; Dawson 1956: 55; Taylor 1950: 139

D. 13639, 13794, 13808, 13838, 13958 (this latter collection consists largely of f. *inerme* (Kützing) Piccone. P. 52–29, Aomon Is. shore rocks, 10/22/52.

Centroceras minimum Yamada; Dawson 1956: 54, fig. 54

D. 13640a, 14009a.

Spyridia filamentosa (Wulfen) Harvey; Dawson 1954: 444, fig. 54i, j; Dawson 1956: 56; Taylor 1950: 139

D. 13677, 13816, 13884, 13911. P. 1163, Mui Is. lagoon, 4/11/54; P. 1190, Bokanjoio Is. lagoon, 4/14/54.

Hypoglossum minimum Yamada 1936: 138, fig. 2A—D (Naha, Okinawa)

Fig. 30*c*

D. 13704, 13755, 13901, 13999d. These show considerable variation in form and habit. Those under 13999d, epiphytic on *Halimeda* from a depth of 135 feet, are most like Yamada's type.

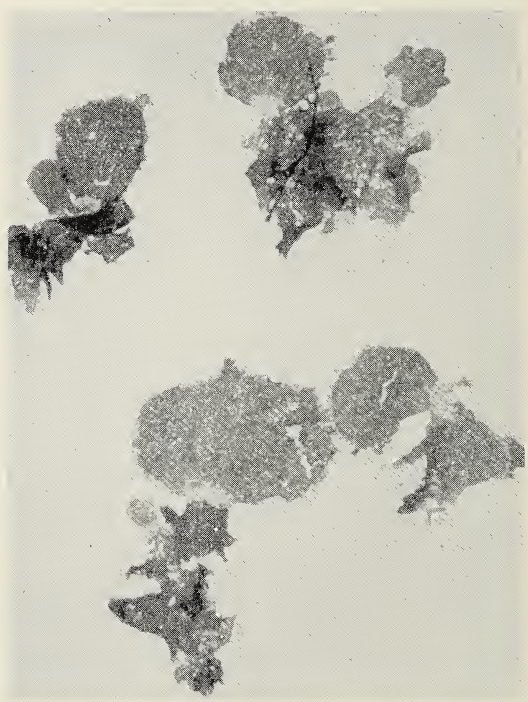


FIG. 28. *Hemitrema fragilis*: Habit of dry plants of D. 13801, × 1.3.

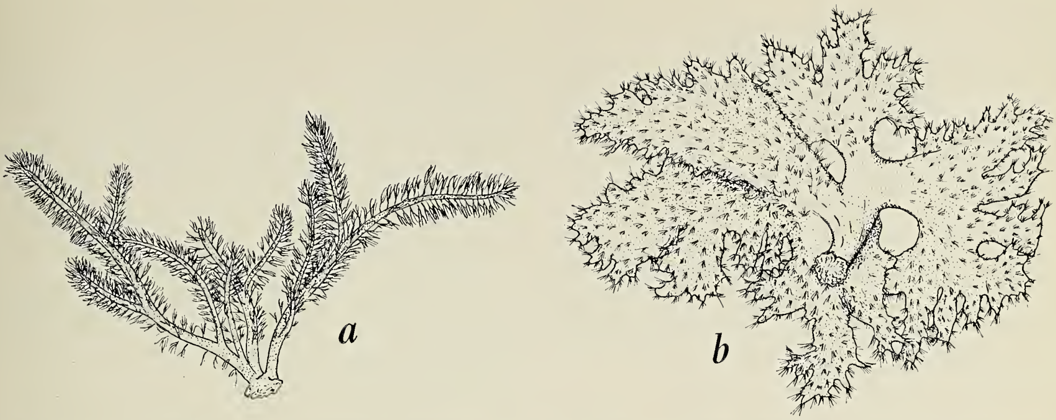


FIG. 29. *a*, *Dasya mollis*, prox.: Habit of a plant of D. 13876, × 4. *b*, *Dasyopsis geppii:* Habit of a young plant of D. 13728 as seen from below, × 3.5.

Taenioma perpusillum (J. Agardh) J. Agardh; Dawson 1954: 451, fig. 58a

D. 14035c. P. 2833a, 1½ mi. off Igurin Is. in the lagoon at 50 ft., 3/16/55.

Hemitrema fragilis (Harvey) comb. nov. *Martensia fragilis* Harvey 1954: 145 (Ceylon); Dawson 1956: 56, fig. 58

Fig. 28

D. 13737, 13801, 14008. Inasmuch as Silva (1952: 291) has pointed out that "*Hemitrema* seems to be the earliest available name for *Martensia*" which is illegitimate, this new combination is called for here.

Dictyurus purpurascens Bory; Dawson 1956: 57; Taylor 1950: 143, pl. 78, fig. 1

D. 13773. P. 2836, Parry Is. seaward reef edge near EMBL, 4/4/54.

Dasya iyengarii Børgesen 1937: 345, figs. 16, 17 (Pam ban Bridge, South India)

Fig. 22*b*

D. 13608, 13624, 13803, 13890, 14051. These specimens are somewhat variable in stature and in detail of branching, but seem to be essentially identical with the south Indian plant. The epiphytic specimens under D. 13608 are especially like the type. Saxicolous specimens under D. 13624 are provided with somewhat more attenuate and less curved and hooked penicilli, but appear otherwise to be like the epiphytic form. The best stands of the plant occur near the margin of the seaward reefs where the species may be dominant in some areas.

Dasya mollis Harvey, prox.; Harvey 1853: 62 (Key West, Florida); Taylor 1928: 173, pl. 26, fig. 13

Fig. 29*a*

D. 13876. This small, completely corticated plant seems best referred here, but the sterile material is insufficient for positive identification. It differs from Atlantic material mainly in the shorter cells of the ramelli.

Dasya adhaerens Yamada 1944: 43, pl. 7, fig. 1 (Ant Atoll, Caroline Islands); Taylor 1950: 141, pl. 79, fig. 1

T. 46–392. Not collected again.

Dasyopsis geppii Weber van Bosse 1913: 130, pl. 13, figs. 18–20, pl. 14, fig. 33 (reefs and to 20–25 fathoms at four Indian Ocean localities indicated)

Fig. 29*b*

D. 13728, 14007. Except for the more pronounced peltate form of some, these agree very well with the account of the "Sealark Expedition" material. Some of them show a

habit more like that of *Dasyopsis palmatifida* W. v B. from the same localities, and suggest further that it is only a variant of *D. geppii.*

Heterosiphonia wurdemannii var. *laxa* Børgesen; Dawson 1956: 57, fig. 60; Taylor 1950: 140 (as *H. wurdemanni*)

D. 13609, 13698, 13739, 13750, 13781, 13760, 13895, 13999. A common small species growing under a variety of conditions and showing variable habit but mostly tending toward Børgesen's var. *laxa.*

Polysiphonia coacta Tseng, prox.; Dawson 1954: 456, fig. 60g, h; Dawson 1956:57

D. 13857d, 13922.

Polysiphonia subtillissima Montagne; Dawson 1954: 454, fig. 60c; Dawson 1956: 58

D. 13904.

Polysiphonia tongatensis Harvey; Dawson 1954: 454, fig. 60d, e; Dawson 1956: 57

D. 13644, 13906, 13933, 13925, 13950c.

Tolypiocladia calodictyon (Harvey) Silva; Dawson 1956: 58, fig. 62; Taylor 1950: 148, pl. 57, fig. 2 (as *Rochera calodictyon*)

D. 13625, 13705, 13881, 13834, 13899, 13957. P. 18129, Runo Is. lagoon at 60 ft., 3/8/55; P. 2500, ¼ mi. off Engebi Is. in lagoon at 15 ft., 3/2/55; P. 2816, s.e. end of Bokanjoio Is. in lagoon at 60 ft., 3/8/55; P. 22x, Runit Is. n.w. tip on channel, 10/22/52; P. 60, off n. tip of Igurin Is. in lagoon at 20 ft., 10/28/52; P. 1153, Engebi Is. lagoon, 4/11/54.

Herposiphonia secunda (C. Agardh) Ambronn; Dawson 1956: 58, fig. 63; Taylor 1950: 148

D. 14002a, growing on the membrane of *Valonia ventricosa.*

Herposiphonia tenella (C. Agardh) Ambronn; Dawson 1954: 452, fig. 59a; Taylor 1950: 147; Dawson 1956: 59

D. 13771a, 13904a, 13914, 14017.

Lophosiphonia bermudensis Collins and Hervey; Dawson 1956: 59, fig. 65

D. 13696, 13903a, 13999a, 14035b. My attention has been called to the fact that Howe (1918: 521) has reduced this species under *Dipterosiphonia rigens* (Schousb.) Falkenb. It appears that a more critical review is called for than can be attempted here.

Lophosiphonia obscura (C. Agardh) Falkenberg; Dawson 1954: 451, fig. 58d, e

D. 13648, 13867. The latter is virtually identical with Børgesen's 1918 figure of tetrasporic material.

Laurencia mariannensis Yamada; Dawson 1956: 60, fig. 66; Taylor 1950: 144, pl. 55, fig. 1

D. 13747. P. 2587a, Aitsu Is., 2/11/55; P. 2832, Igurin Is. lagoon at 50 ft., 3/16/55.

Laurencia nana Howe 1920: 566 (Mariguana, Bahamas)

Fig. 30*a*

D. 13725. These fertile specimens are in excellent agreement with Howe's description, including the palisade cortical cells, the presence of rhizoidal haptera and the lack of lenticular thickenings.

Laurencia parvipapillata Tseng; Dawson 1954: 458, fig. 61g

D. 13754, 13964. P. 2833, Igurin Is. lagoon at 50 ft., 3/16/55.

Chondria minutula Weber van Bosse 1923: 349, pl. 10, figs. 10, 12 (Tanah Djampea Is., Indonesia)

Fig. 30*d*, *e*

D. 13744, 13771, 13932a, 13788a. The tetrasporic and cystocarpic material seems to agree well with Weber van Bosse's account of the type which had a similar creeping habit and the same stature.

Chondria polyrhiza Collins and Hervey 1917: 121, pl. 2, fig. 12 (Bermuda)

Fig. 30*b*

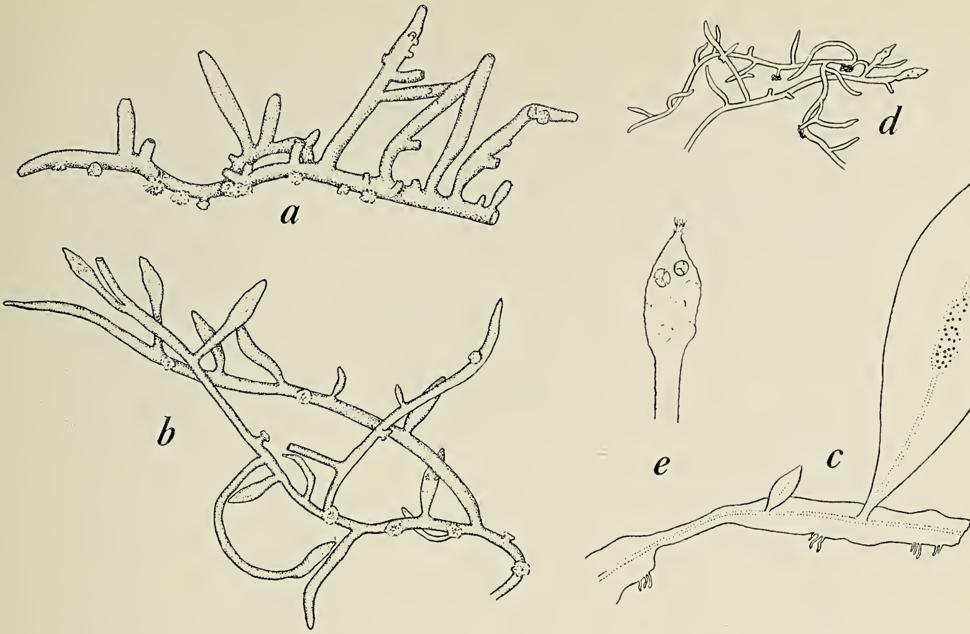


FIG. 30. *a*, *Laurencia nana:* Habit of a plant of D. 13725, × 4. *b*, *Chondria polyrhiza:* Habit of a plant of D. 13795 from the under side, × 10. *c*, *Hypoglossum minimum:* Part of a tetrasporangial plant of D. 13704 showing rhizoids, branching from the midrib, and a sorus, × 6. *d*, *e*, *Chondria minutula: d*, Habit of a plant of D. 13744, × 5; *e*, detail of the apex of a tetrasporic branch of the same showing the emergent tip and trichoblasts, × 35.

D. 13795. This seems to fit the Collins and Hervey description and figures well. Under D. 14027 two forms are present, one with axes to 450 μ in diameter and with rather blunt tips, the other with axes only about 220 μ in diameter and more attenuate tips. They probably represent growth stages.

Chondria repens Børgesen; Dawson 1954: 460, fig. 62d, e; Dawson 1956: 60
D. 13932.

BLUE-GREEN ALGAE

Anacystis dimidiata (Kützing) Drouet and Daily 1952: 221. *Trochiscia dimidiata* Kützing 1833: 593, fig. 75 (Germany). Taylor 1950: 103 (as *Gloeocapsa turgida* (Kütz.) Hollerbach [*Chroococcus turgidus* (Kütz.) Nägeli])

Fig. 31*a*

P. 2830, Igurin Is. scum on rocks in lagoon at 50 ft., 3/16/55.

Coccochloris stagnina Sprengel 1807: 14 (Halle, Germany)

Fig. 31*b*

D. 13893, 14043. P. 1235–6, Bogombogo Is. lagoon, 4/22/54; P. 2801, Bokanjoio Is. seaward flats. 10/25/54.

Gomphosphaeria aponina Kützing 1836: Dec. 16, no. 151 (Abano, Italy); Taylor 1950: 103

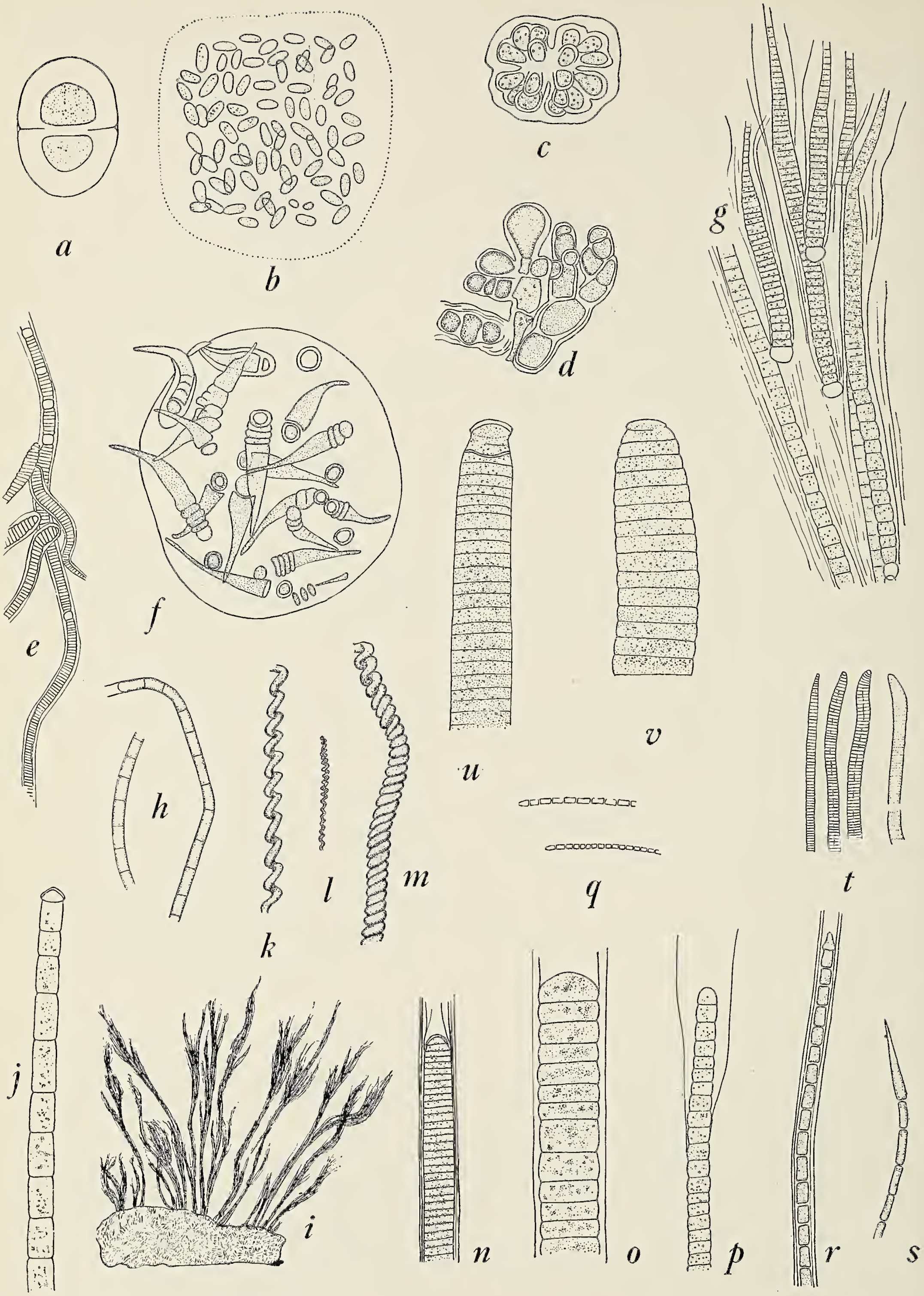
Fig. 31*c*

T. 46–316. Not collected again.

Entophysalis conferta (Kützing) Drouet and Daily; Dawson 1954: 379, fig. 3r
D. 13664.

Entophysalis deusta (Meneghini) Drouet and Daily 1948: 79. *Coccochloris deusta* Meneghini 1841: 173 (Genoa, Italy). Taylor 1950: 104 (as *E. granulosa* Kütz.)

Fig. 31*d*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D. 13673, 13878b.

Hormothamnion enteromorphoides Grunow seq. Bornet and Flahault; Dawson 1954: 379, fig. 3n; Taylor 1950: 105
D. 13680, 13682. P. 22, Rigili Is., 8/10/49.

Plectonema nostocorum Bornet seq. Gomont 1893: 102, pl. 1, fig. 11 (type not indicated); Taylor 1950: 105.
T. 46–304. Not collected again.

Plectonema terebrans Bornet and Flahault seq. Gomont 1893: 103 (Le Croisic, Atlantic France)

D. 13878a, 14020. P. 2830, Igurin Is. lagoon rocks at 50 ft., 3/16/55.

Scytonema polycystum Bornet and Flahault 1887: 90 (Noumea, New Caledonia)
D. 13955.

Scytonema myochrous (Dillwyn) C. Agardh seq. Bornet and Flahault is reported by Palumbo 1950 from Eniwetok without locality, based upon a determination by F. Drouet.

Calothrix crustacea Thuret seq. Bornet and Flahault 1886: 359 (Le Croisic, Atlantic France)

Fig. 31*e*

D. 13621, 13662, 13687, 13868.

Rivularia atra Roth seq. Bornet and Flahault 1886: 353 (Europe)

Fig. 31*f*

D. 13663.

Rivularia polyotis (J. Agardh) seq. Bornet and Flahault 1886: 360 (Mediterranean Sea)

Fig. 31*g*

D. 14034.

Phormidium crosbyanum Tilden 1910: 96, pl. 4, figs. 60, 61 (Waianae, Oahu, Hawaiian Islands); Taylor 1950: 109

Fig. 31*h*

D. 13670, 13880, 14052. P. 2800, Mui Is. seaward flats, 10/21/54; P. 2841, Eneroul Is. seaward flats, 9/23/54; P. 2818, Bokanjoio Is. sand flats on east side, 3/8/55.

Phormidium penicillatum Gomont 1893: CLIX, pl. IV, figs. 5–7 (Borbon Is., Mascarene Islands)

Fig. 31*i*, *j*

D. 13714, 13780, 13963.

Oscillatoria nigro-viridis Harvey seq. Gomont; Dawson 1954: 380, fig. 3g
D. 13686.

Spirulina major Kützing seq. Gomont 1893: 251, pl. 7, fig. 29 (Germany)

Fig. 31*k*

D. 13885.

Spirulina subsalsa Oersted seq. Gomont 1893: 253, pl. 7, fig. 32 (Denmark)

Fig. 31*m*

D. 13662a, 13846.

◄ FIG. 31. *a*, *Anacystis dimidiata:* × 600 approx. (after West). *b*, *Coccochloris stagnina:* × 600 approx. (after Lemmermann). *c*, *Gomphosphaeria aponina:* × 600 approx. (after West). *d*, *Entophysalis deusta:* × 600 approx. (after (Engler and Prantl). *e*, *Calothrix crustacea:* × 500 approx. (after Bornet and Thuret). *f*, *Rivularia atra:* × 600 approx. (after Wille). *g*, *Rivularia polyotis:* × 600 approx. (after Bornet and Thuret). *h*, *Phormidium crosbyanum:* × 600 approx. (after Tilden). *i*, *j*, *Phormidium penicillatum: i*, Habit, × 0.8; *j*, detail of a trichome, × 580 (after Bornet). *k*, *Spirulina major:* × 600 approx. (after Gomont). *l*, *Spirulina tenerrima:* × 600 approx. *m*, *Spirulina subsalsa:* × 600 approx. (after Gomont). *n*, *Lyngbya semiplena:* × 600 approx. (after Gomont). *o*, *Lyngbya sordida:* × 600 approx. (after Gomont). *p*, *Lyngbya gracilis:* × 600 approx. (after Gomont). *q*, *Schizothrix lacustris:* × 600 approx. (after Gomont). *r*, *Symploca laeteviridis:* × 600 approx. (after Gomont). *s*, *Microcoleus tenerrimus:* × 600 approx. (after Gomont). *t*, *Hydrocoleum glutinosum:* × 600 approx. (after Kützing). *u*, *Hydrocoleum comoides:* × 600 approx. (after Gomont). *v*, *Hydrocoleum cantharidosmum:* × 600 approx. (after Gomont).

Spirulina tenerrima Kützing seq. Gomont 1893: 252 (Europe)

Fig. 31*l*

D. 13799, 13970.

Lyngbya aestuari (Mertens) Liebmann seq. Gomont; Dawson 1954: 380, fig. 3a; Taylor 1950: 110
D. 13659, 13684, 13855, 13878, 13984.

Lyngbya confervoides C. Agardh seq. Gomont; Dawson 1954: 380, fig. 3b, c; Taylor 1950: 110
D. 13940, 14038.

Lyngbya majuscula (Dillwyn) Harvey seq. Gomont; Dawson 1954: 380, fig. 3d; Taylor 1950: 111
D. 13646, 13690, 13784, 13844, 13848, 13882, 13960, 13965, 13985. P. 2853, Rigili Is. sea beach, 11/17/54; P. 14, Engebi Is. n.w. end at 6 ft., 8/11/49; P. 2828, Igurin Is. 1½ mi. off at 50 ft., 3/8/55.

Lyngbya meneghiniana (Kützing) seq. Gomont 1893: 125 (Europe); Taylor 1950: 109
D. 13681, 13683, 13885a, 13984a.

Lyngbya semiplena (C. Agardh) J. Agardh seq. Gomont 1893: 138, pl. 3, figs. 7–11 (Adriatic Sea)

Fig. 31*n*

D. 13686a, 14041. P. 57b, Rigili Is. seaward pavement, 10/27/52.

Lyngbya sordida (Zanardini) seq. Gomont 1893: 126, pl. 2, fig. 21 (Venice, Italy); Taylor 1950: 110, pl. 79, fig. 2

Fig. 31*o*

D. 13789, 13931, 13966, 14030. P. 52–18, Runit Is. flats at w. tip, 10/22/52. P. 52–104, Aaraanbiru Is. lagoon s.w. end, 11/7/52.

Lyngbya sordida f. *bostrychicola* Crouan seq. Gomont 1893: 126 (near Brest, France)
D. 13783.

Lyngbya gracilis (Meneghini) Rabenhorst seq. Gomont 1893: 124, pl. 2, fig. 20 (Atlantic France); Taylor 1950: 109

Fig. 31*p*

T. 46–421. Not collected again.

Schizothrix lacustris A. Braun seq. Gomont 1892: 301, pl. 6, figs. 9–12 (Germany); Taylor 1950: 112

Fig. 31*q*

T. 46–333, Runit Is. seaward reef flat, May 1946. Not collected again.

Symploca hydnoides Kützing seq. Gomont; Dawson 1954: 380, fig. 3o, p
D. 13641, 13689, 13839, 13993, 14042. P. 2839, Runit Is. n.w. tip flats in channel, 10/22/52; P. 2809, Bokanjoio Is. lagoon, 3/8/55; P. 2838, Mui Is. lagoon, 4/11/54; P. 1151, Runit Is. n. tip channel, 4/11/54; P. 2843, Bogombogo Is. seaward flats, 10/5/54.

Symploca laete-viridis Gomont 1893: 109, pl. 2, figs. 6–8 (Key West, Florida); Taylor 1950: 113

Fig. 31*r*

D. 13833.

Microcoleus tenerrimus Gomont 1892: 355, pl. 14, figs. 9–11 (France)

Fig. 31*s*

D. 13659a, 13872.

Hydrocoleum coccineum Gomont 1892: 342, pl. 13, figs. 1, 2 (on *Codium* Antibes, Mediterranean Sea); Taylor 1950: 115
D. 13779. This species is similar to *H. lyngbyaceum* but differs in its red to pale blue-green protoplasm (bright blue-green, olive

or yellow green in *H. lyngbyaceum*). In the latter the cross walls are granulated unlike *H. coccineum*.

Hydrocoleum glutinosum (C. Agardh) Gomont 1892: 339 (Sweden)

Fig. 31*t*

D. 13661, 13668, 13756, 13842.

Hydrocoleum comoides (Harvey) seq. Gomont 1892: 335, pl. 12, figs. 3–5 (Australia); Taylor 1950: 115

Fig. 31*u*

D. 13638, 13685, 13688, 13716, 13733.

Hydrocoleum lyngbyaceum Kützing seq. Gomont; Dawson 1954: 380, fig. 3q

D. 13653, 13667, 13671, 13827, 13870. P. 2543, Runo Is. seaward reef, 3/8/55; P. 2802, Bokanjoio Is. seaward flats, 10/25/54; P. 2810, Bokanjoio Is. lagoon, 3/8/55; P. 2823, Bokanjoio Is. seaward reef, 3/8/55; P. 2852, Mui Is. lagoon, 11/17/54; P. 2856, Aitsu Is. lagoon, 11/17/54.

Hydrocoleum cantharidosmum (Montagne) seq. Gomont 1892: 336, pl. 12, figs. 6, 7 (Canary Islands); Taylor 1950: 116

Fig. 31*v*

T. 46–312. Not collected again.

REFERENCES

ABBOTT, ISABELLA. 1946. The genus *Griffithsia* in Hawaii. *Farlowia* 2(4): 439–453, 4 pls.

AGARDH, C. A. 1828. *Species algarum* . . . Vol. 2, pt. 1. lxxvi + 189 pp. E. Mauritii, Gryphiswaldae.

AGARDH, J. G. 1847. Nya alger från Mexico. *Svenska Vetensk. Akad., Öfversigt af Forhandl.* 1847(1): 5–17.

——— 1872. Till algernes systematik, Nya Bidrag, Första Afd. *Lunds Univ. Årsskr.* 9(8): 1–71.

——— 1887. Till algernes systematik, Nya Bidrag, Femte Afd. *Lunds Univ. Årsskr.* 23: 1–174, 5 pls.

ASKENASY, E. 1888. Algen . . ., In *Die Forschungsreise S. M. S. "Gazelle" 1874-bis 1876* . . . Bot. 4: 1–58, pls. 4–12. E. Siegfried, Mittler et Sohn, Berlin.

BARTON, ETHEL. 1901. The genus *Halimeda*. *Siboga Expeditie*. Monog. 60. 32 pp., 4 pls. E. J. Brill, Leiden.

BØRGESEN, F. 1914. Marine algae of the Danish West Indies II. Phaeophyceae. *Dansk Bot. Arkiv.* 2(2): 159–222, figs. 127–170.

——— 1915–20. The marine algae of the Danish West Indies III. Rhodophyceae. *Dansk Bot. Arkiv.* 3(1): 1–504, 435 figs.

——— 1924. Marine algae from Easter Island. In C. Skottsberg, *The Natural History of Juan Fernandez and Easter Island* 2(9): 247–309. Almqvist & Wiksells, Uppsala.

——— 1934. Some marine algae from the northern part of the Arabian Sea with remarks on their geographical distribution. *K. Danske Vidensk. Selsk., Biol. Meddel.* 11 (6): 1–72. 8 figs. 2 pls.

——— 1937. Contributions to a South Indian marine algal flora. II. *Indian Bot. Soc., Jour.* 16(6): 311–357, 20 figs.

——— 1938. Contributions toward a South Indian marine algal flora. III. *Indian Bot. Soc., Jour.* 17(4): 205–242, 13 figs. 2 pls.

——— 1940. Some marine algae from Mauritius. 1. Chlorophyceae. *K. Danske Vidensk. Selsk., Biol. Meddel.* 15(4): 1–81, 3 pls.

——— 1941. Some marine algae from Mauritius. II. Phaeophyceae. *K. Danske Vidensk. Selsk., Biol. Meddel.* 16(3): 1–81, 8 pls.

BORNET, E., and C. FLAHAULT. 1886–88. Revision des Nostocacées Hétérocystées. *Ann. des Sci. Nat.* VII, *Bot.*, pt. 1, 1886(3): 323–380; pt. 2, 1886(4): 343–373; pt. 3, 1887(5): 51–129; pt. 4, 1888(7): 177–262.

BUTTERS, F. K. 1911. Notes on the species of *Liagora* and *Galaxaura* of the central Pacific. *Minn. Bot. Studies* 4: 161–184, pl. 24.

CHAUVIN, J. F. 1842. *Recherches sur l'organization, la fructification et la classification de plusieurs genres d'algues* . . . 132 pp. Caen.

COLLINS, F. S., and A. B. HERVEY. 1917. The algae of Bermuda. *Amer. Acad. Arts and Sci., Proc.* 53(1): 1–195, 6 pls.

DAWSON, E. Y. 1949. Contributions toward a marine flora of the southern California Channel Islands, I–III. *Allan Hancock Found. Pub., Occas. Papers* (8): 1–57, 15 pls.

——— 1954. Marine plants in the vicinity of the Institute Océanographique de Nha Trang, Viêt Nam. *Pacific Sci.* 8(4): 373–469, 1 map, 63 figs.

——— 1954a. The marine flora of Isla San Benedicto following the volcanic eruption of 1952–53. *Allan Hancock Found. Pub., Occas. Papers* (16): 1–25, 5 pls.

——— 1956. Some marine algae of the southern Marshall Islands. *Pacific Sci.* 10(1): 25–66, 66 figs.

DAWSON, E. Y., A. A. ALEEM, and B. W. HALSTEAD. 1955. Marine algae from Palmyra Island with special reference to the feeding habits and toxicology of reef fishes. *Allan Hancock Found. Pub., Occas. Papers* (17): 1–39, 1 map, 13 figs.

DECAISNE, M. J. 1842. Mémoire sur les corallines ou polypiers calciféres. *Ann. des Sci. Nat.* II, *Bot.* 18: 96–128.

DELILE, A. RAFFENEAU. 1813. Florae Eyptiacae illustratio (pp. 49–82); Flore de l'Egypte, explication des planches (pp. 145–320). In [France] *Commision d'Egypte. Description de l'Egypte, on recueil des observations et des recherches qui ont été faites en Egypte pendant l'expedition de l'armée Française 1798–1801*. Vol. 2. Paris.

DILLWYN, L. W. 1802–1809. *British Confervae* . . . 87 pp., pls. 1–109, A–G. W. Phillips, London.

DROUET, F., and W. A. DAILY. 1948. Nomenclatural transfers among coccoid algae. *Lloydia* 11: 77–79.

——— and ——— 1952. A synopsis of the coccoid Myxophyceae. *Butler Univ. Bot. Studies* 10: 220–223.

EGEROD, LOIS. 1952. An analysis of the siphonous Chlorophycophyta . . . *Calif. Univ., Pubs., Bot.* 25(5): 325–545, 14 pls.

FELDMANN, J., and G. HAMEL. 1934. Observations sur quelques Gelidiacées. *Rev. Gén. de Bot.* 46(1934): 528–550.

FOSLIE, M. H. 1900. New or critical calcareous algae. *Norske Vidensk. Selsk., Skr.* 1899(5): 1–34.

——— 1907. Lithothamnia of the Percy Sladen Trust Expedition, in H.M.S. "Sealark." *Linn. Soc. London, Trans.* II, *Zool.* 12(2): 177–192, pls. 19, 20.

——— 1909. Algologiske Notiser VI. *Norske Vidensk. Selsk., Skr.* 1909(2): 1–63.

GEPP, A., and ETHEL GEPP. 1911. Codiaceae of the Siboga Expedition. *Siboga Expeditie.* Monog. 62. 150 pp., 22 pls. E. J. Brill, Leiden.

GOMONT, M. 1892–93. Monographie des Oscillariées. *Ann. des Sci. Nat., Bot.* VII, 15(1): 263–368, pl. 6–14; 16(2): 91–264, pl. 1–7 (reprint 1893, pp. 1–302).

——— 1893a. Nostocacées homocystées. In F. Jadin, Algues des Iles Mascareignes . . . *Soc. Bot. de France, Bul.* 40: cxlviii-clxxiii.

HAMEL, G. 1931. Chlorophycées des côtes françaises (suite). *Rev. Algologique* 5: 383–430.

HARVEY, W. H. 1853. Nereis Boreali-Americana . . . Part II. Rhodospermae and appendix. *Smithsn. Inst., Contrib. Knowl.* 5(5): 1–258, 24 pls.

——— 1854. Short characters of three new algae from the shores of Ceylon. *Jour. Bot.* [Hooker] 6: 143–145.

——— 1858. Nereis Boreali-Americana . . . Part III. Chlorospermae, and Supplement. *Smithsn. Inst., Contrib. Knowl.* 10: 1–140, pls. 37–50.

——— 1859. Characters of new algae, chiefly from Japan and adjacent regions . . . *Amer. Acad. Arts and Sci., Proc.* 4: 327–334.

——— 1862. *Phycologia Australica* . . . Vol. 4. Pp. [i]–viii, pls. 181–239. L. Reeve & Co., London.

HAUCK, F. 1887. Ueber einige von J. M. Hildebrandt im Rothem Meere und Indischen Ocean gesammelte Algen. *Hedwigia* 26: 41–45.

HEYDRICH, F. 1897. Corallinaceae, insbesondere Melobesiaceae. *Ber. der Deut. Bot. Gesell.* 15(7): 34–70, pl. 3.

HOWE, M. A. 1918. Class 3. Algae [pp. 489–540]. In N. L. Britton, *Flora of Bermuda.* xi + 585 pp. Charles Scribners Sons, New York.

——— 1920. Class 2. Algae [pp. 553–618]. In N. L. Britton and C. F. Millspagh, *The Bahama Flora.* viii + 695 pp. Published by the authors, New York.

KANDA, T. 1944. Ecological studies of marine algae from Korôru and adjacent islands in the south sea islands. *Palao Tropical Biol. Studies* II (4): 733–800.

KÜTZING, F. T. 1833. Synopsis diatomearum oder Versuch einer systematischen Zusammenstellung der Diatomeen. *Linnaea* 8: 529–620, figs. 1–102.

——— 1833–36. *Algarum aquae dulcis Germaniae* Decades I-XVI. Halle. [Exsiccatae with text.]

——— 1845. *Phycologia germanica.* 340 pp. W. Köhne, Nordhausen.

——— 1845–71. *Tabulae Phycologicae* . . . Vols. 1–19 + index. 1900 pls. W. Köhne, Nordhausen.

——— 1849. *Species algarum.* 922 pp. F. A. Brockhaus, Leipzig.

KYLIN, H. 1944. Die Rhodophyceen der Schwedischen Westkuste. *Lunds Univ. Årsskr.*, N. F. 40(2): 1–104, 32 pls.

LAMOUROUX, J. V. 1809. Mémoire sur trois nouveaux genres de la famille des algues marines . . . *Jour. de Bot.* [Desvaux] 2: 129–135, 1 pl.

——— 1809a. Sur la physiologie des algues marines, et description de cinq nouveaux genres de cette famille. *Soc. Philom., Paris, Nouv. Bul. de Sci.* 1: 330–333, pl. 6, fig. 2A–D.

LYNGBYE, H. C. 1819. *Tentamen hydrophytologiae Danicae* . . . xxxii + 248 pp., 70 pls. Typis Schultzianis, in commissis Librariae Gyldendaliae, Hafniae.

MARTENS, G. von. 1866. *Die Preussische Expedition nach Ost-Asien . . . Bot. Theil. Die Tange.* iv + 152 pp., 8 pls. K. Geheime, Berlin.

MONTAGNE, C. 1838. De l'organisation et du mode de reproduction des Caulerpées, et en particular du *Caulerpa Webbiana*, espèce nouvelle des îles Canaries. *Ann. des Sci. Nat., Bot.* 9: 129–150.

——— 1845. Plantes cellulaires, vol. 1: i–xiv, 1–349. In [France], *Voyage au pole sud . . . sur les corvettes l'Astrolabe et la Zelee . . . Botanique.* Gide et Cie., Paris.

ODUM, H. T., and E. P. ODUM. 1955. Tropic structure and productivity of a windward coral reef community on Eniwetok Atoll. *Ecol. Monog.* 25: 291–320.

OKAMURA, K. 1913–15. *Icones of Japanese algae.* Vol. 3, pp. 1–218, pls. 101–150. Published by the author, Tokyo.

PALUMBO, R. F. 1950. Section IX, Algae, pp. 108–118. In Radiobiological Survey of Bikini, Eniwetok, and Likiep Atolls, July-August 1949. *United States Atomic Energy Comn. Doc.* 3446, pp. 1–145. Dept. of Commerce, Washington, D. C.

PAPENFUSS, G. F. 1947. Further contributions toward an understanding of the *Acrochaetium-Rhodochorton* complex of the red algae. *Calif. Univ., Pubs., Bot.* 18(19): 433–447.

REINBOLD, T. 1901. Marine algae (Chlorophyceae, Phaeophyceae, Dictyotales, Rhodophyceae). In J. Schmidt, Flora of Koh Chang (Siam) Pt. IV. *Bot. Tidsskr.* 24: 187–201.

SETCHELL, W. A., and N. L. GARDNER. The marine algae. Expedition of the California Academy of Sciences to the Gulf of California in 1921. *Calif. Acad. Sci., Proc.* IV, 12: 695–949, 77 pls.

SILVA, P. C. 1952. A review of nomenclatural conservation in the algae from the point of view of the type method. *Calif. Univ., Pubs., Bot.* 25(4): 241–324.

SMITH, G. M. 1944. *Marine algae of the Monterey Peninsula, California.* 622 pp., 98 pls. Stanford University Press, Stanford, Calif.

SPRENGEL, C. 1807. *Mantissa prima Florae Halensis, addita novarum plantarum Centuria.* 58 + 31 pp. Halae Saxonum, Kümmel.

TAYLOR, W. R. 1928. Marine algae of Florida with special reference to the Dry Tortugas. *Carnegie Inst. Wash., Pub.* 25 (pub. 379): 1–219, 37 pls.

——— 1950. *Plants of Bikini and other northern Marshall Islands.* xv + 227 pp., 79 pls. University of Michigan Press, Ann Arbor.

TILDEN, JOSEPHINE. 1910. *Minnesota Algae Vol. 1. The Myxophyceae of North America and adjacent regions* . . . iv + 328 pp., 20 pls. Minneapolis, Minnesota.

TURNER, D. 1808–1819. *Fuci* . . . Vol. 1 (1808), 164 pp., 71 pls. Vol. 2 (1809), 162 pp., pls. 72–134. Vol. 3 (1811), 148 pp., pls. 135–196. Vol. 4 (1819), 153 pp., pls. 197–258. J. M'Creery, London.

WEBER VAN BOSSE, ANNA. 1898. Monographie des Caulerpes. *Buitenzorg Jard. Bot., Ann.* 15(2): 243–401, pls. 20–34.

——— 1905. Note sur le genre *Dictyosphaeria* Dec. *Nuova Not.* 16: 142–144.

——— 1913. Marine algae, Rhodophyceae, of the "Sealark" Expedition . . . *Linn. Soc. London, Trans.* II, *Bot.* 8(1): 105–142, 3 pls.

——— 1923. Liste des algues du Siboga. II, Rhodophyceae, seconde partie, Ceramiales, pp. 311–392, pls. 9, 10. *Siboga Expeditie* Monog. 59. E. J. Brill, Leiden.

——— 1926. Algues de l'Expedition danoise aux îles Kei. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–1916. XXXIII. *Dansk Naturhist. For. Kjøbenhavn, Vidensk. Meddel.* 81: 57–155, 43 figs.

YAMADA, Y. 1936. Notes on some Japanese algae VII. *Hokkaido Imp. Univ., Inst. Algol. Res., Sci. Papers* 1(2): 135–140, 4 pls.

——— 1938. The species of *Liagora* from Japan. *Hokkaido Imp. Univ., Inst. Algol. Res., Sci. Papers* 2(1): 1–34, 15 pls.

——— 1941. [Species of *Caulerpa* in the South Sea] *Kaguku Nanyo* 4: 95–105, figs. 1–16.

——— 1944. A list of the marine algae from the atoll of Ant. *Hokkaido Imp. Univ., Inst. Algol. Res., Sci. Papers* 3(1): 31–45, pls. 6, 7.

YAMADA, Y., and T. TANAKA. 1938. The marine algae from the island of Yonakuni. *Hokkaido Imp. Univ., Inst. Algol. Res., Sci. Papers* 2(1): 53–86, 13 figs.

ZANARDINI, G. 1847. *Notizie intorno alle cellulari marine delle lagune e de'litorali di Venezia.* 88 pp., 4 pls. Venice.

——— 1872. Phycearum indicarum pugillus . . . *Ist. Veneto di Sci. Let., ed Arti., Mem.* 17: 129–170, 12 pls.

NOTES

Sexual Dimorphism in the Labrid Fish Genus *Gomphosus*[1]

During an examination of the viscera of Marshallese fishes the writers' attention was drawn to the fact that all of our specimens of *Gomphosus varius* in which the sex could be determined were females, and that all specimens of *G. tricolor* were males. Suspecting the possibility of sexual dimorphism, we collected additional material, so that this study of *Gomphosus* ultimately included 56 specimens from Eniwetok, 4 from Bikini, 3 from Arno (all atolls in the Marshall Islands), and 15 from Oahu and Kauai in the Hawaiian Islands. Seven Marshallese and 3 Hawaiian specimens were *tricolor*, according to various descriptions; 14 Marshallese specimens were the distinctively marked juveniles of *varius*; and the remaining 54 were typical *varius*. Eight of the 10 *tricolor* proved to be males, one was decomposed internally, and another was too immature to be sexed. Sex could not be determined for any of the 14 juvenile *varius*, but 39 of the larger specimens were females in various stages of maturity while 15 were immature and could not be sexed.

The major taxonomic difference between *tricolor* and *varius* is color and color pattern. In life *tricolor* is a rich blue-green with a vertical yellow-green bar across the trunk near the pectoral insertion. Its head and caudal fin tend to be rather more bluish than the rest of the body, and in large specimens the caudal fin is somewhat lunate. *G. varius* is somberly colored in comparison, being plain black posteriorly and creamy white to light brown anteriorly, each antero-dorsal scale having a dark spot at its base. The breast and cheeks are white or cream, the snout tip is reddish, and a narrow black stripe runs the length of the head at the level of the pupil. Small juveniles of *varius* are bright yellow-green dorsally, plain white laterally and ventrally, and have a pair of lengthwise black stripes from the snout tip to the caudal base. They also differ from larger specimens in that they either lack or are just developing the elongate snout characteristic of the genus. Jordan and Evermann (1905. *U. S. Fish Comm.*, *Bul.* 23: pl. 36) present a color plate of *tricolor* and in the same work (*op. cit.*, p. 289, fig. 125) a black and white drawing of *varius*.

In size, our *tricolor* range from 104 to 166 mm. in standard length, whereas typical *varius* range from 38 to 134 mm. From about 30 to 40 mm. the *varius* and juvenile color patterns intergrade, our largest true juvenile measuring 36 mm. and the smallest 23 mm. Similarly, but on the other end of the scale, our smaller *tricolor* show unmistakable vestiges of a *varius* color pattern, the persistent elements being the basal dark spots on the anterior trunk scales. These spots are more obvious in preserved material than in fresh specimens but some indication of their presence occurs on all *tricolor* examined. The largest *tricolor* have slightly lunate caudal fins, a condition often appearing with age or sex in fishes, and here it is apparently restricted to the male.

Meristic data are the same for the two forms, based on 10 *tricolor* and 19 *varius*. Dorsal rays are VIII, 13; anal rays III, 11 (the first spine is imbedded) although one *tricolor* had only 10 anal rays; pectoral rays are 16, including the short bony splint at the top of the fin, with an occasional specimen having 15 or 17 rays; and lateral line scales are 27. The gill arches are C-shaped and not readily divisible into upper and lower limbs. Gill rakers totalled 24 for the first arch in the two *varius* and two *tricolor* examined for this feature.

The above facts point to the hypothesis that in the Hawaiian and Marshall Islands, at least, the species of *Gomphosus* hitherto regarded as *tricolor* and *varius* are in reality the two sexes of the same species. Apparently *tricolor* represents mature and nearly mature males while *varius* includes all females and probably also young males (even though no recognizable males were found with typical *varius* coloration). Mature males are somewhat larger than the largest fe-

[1] This paper is Contribution No. 86, Hawaii Marine Laboratory, in cooperation with the Department of Zoology and Entomology, University of Hawaii. The senior author was a member of the staff of Duke University at the time the work was done. Manuscript received August 7, 1956.

males and also tend to have lunate caudal fins. More than likely an histological examination of the gonads of small "*varius*" would show both sexes displaying the *varius* or juvenile color pattern.

Marked sexual dimorphism, expressed as coloration differences, is not unusual among the labroid fishes. Longley (Longley and Hildebrand, 1941. Papers from Tortugas Lab. 34: 196–198) showed that in *Thalassoma bifasciatum* only adult males attain the *bifasciatum* color pattern, whereas females and young males exhibit a coloration so characteristic that they were long called *T. nitidum*. Recently Randall (1955. *Copeia* 3: 237) has demonstrated that *Stethojulis renardi* is merely the adult male of *S. strigiventer*, and Brock and Yamaguchi (1954. *Copeia* 2: 154–155) have shown that *Scarus ahula* is the female of *S. perspicillatus*. The latter authors contrast the bright blue, green, and yellow pattern of male *perspicillatus* with the rather drab pattern of the female, a situation quite similar to that obtaining in *Gomphosus*.

One line of evidence which seems to cast doubt on our hypothesis that *tricolor* and *varius* are dimorphic forms of the same species is their pattern of distribution and relative abundance. In the 2-to 35-foot depth range sampled for this study *tricolor* occurred mostly in deeper water and was uncommon even there. *G. varius*, on the other hand, seemed to be uniformly distributed throughout this range and was common to abundant. Every rotenone or sight-observation station yielding *tricolor* also produced *varius*, but the reverse was certainly not true. Disjunctive distributions and aberrant sex ratios such as those found in this study do not necessarily indicate that *varius* and *tricolor* are separate species, particularly in view of Gosline and Strasburg's recent work (1956. *Copeia* 1: 9–18), on the even more markedly dimorphic Hawaiian moringuid eels.

The name to be applied to our *Gomphosus* cannot be verified at this time. *Gomphosus varius* Lacepede (1802. *Hist. Nat. Poiss.* 3:100, 104) predates *G. tricolor* Quoy and Gaimard (1824. Voyage *Uranie*, Zool.: 280), the type localities being Tahiti and the Hawaiian Islands respectively. We accordingly refer our material to *varius*, but with the following reservation. In the Indian Ocean the central Pacific forms of *Gomphosus* are replaced by two or three other species, one or two of which may be identical with the Pacific *varius*. Based on our experience it would appear that sexual dimorphism is also present in the Indian Ocean *Gomphosus*, and that males may occur as either the blue-green *tricolor* form or as a violet-blue species called *coeruleus*. The precise relationship of the Indian Ocean to the Pacific *Gomphosus* remains to be demonstrated. When this is done it may be that what we here call *varius* will be synonymized with *coeruleus*.

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DR. ELMER D. MERRILL, 1876–1956

Last year marked the passing of the outstanding bibliographer of the Pacific area, Dr. E. D. Merrill, botanist, bibliographer, and administrator; man of prodigious energy, broad vision, and deep understanding of problems and people; and a valued friend.

I wish here to pay tribute to the memory of the man to whom we owe so much. Extracts from his contributions to science were republished with subsidiary material in Chronica Botanica[1] at a time when he could still appreciate the honor. His autobiography of his Philippine and California days was published in the Asa Gray Bulletin.[2] Thus most of the essential facts concerning this leader and builder need no further elaboration.

Before December, 1928 Dr. Merrill was to me just the great man who had been Director of the Bureau of Science in Manila and who had developed Philippine botany and the great herbarium in the capital of those islands. He was the one who by then had undertaken the study of the flora of Hainan, and had stimulated the study of botany in many institutions in China, especially by the Chinese themselves. To him had gone all collections made at Lingnan University, Canton, China, where I had taught from 1922 to 1926. He was dean of the Agricultural College of the University of California in June 1928, when I became an aide in the Division of Plants, U.S. National Herbarium, Smithsonian Institution. I was employed to bring order out of the large and partly worked Chinese and other Asiatic collections. Thus I joined the ranks of the very small number of workers on the botany of China. Dr. Merrill was out front, I far in the rear. However, on a trip to Washington he came around to "look me over." With his characteristically direct question, "What are you doing about the literature?", I started with almost no previous experience in this field to become a bibliographer. A year later we became collaborators in the "Bibliography of Eastern Asiatic Botany," which left the press nearly ten years later. My association with Dr. Merrill continued until his death.

Dr. Merrill's two most outstanding characteristics were breadth of vision and limitless capacity for work. He began in Manila with nothing but his own strong qualities. Before that field was well under way he had reached out to small but important Amboina in the East Indies, unknown Borneo, American possessions in the Pacific Islands, notably Guam, and then Hainan Island and China. His influence was felt in institutions in Europe, America, and Asia. To some he is a symbol of over-extension, leaving a trail of unfinished works behind him. But he left the polish and fine points to others who could not see the need for plowing widely if not deeply, in other fields related to his own. Indeed he was extended, yet he knew this limitation. "Here it is," he said, "as far as I can do it with my limited time and resources. Let others pick up from here." So ran his philosophy. Then he turned to other things, leaving behind him, it is true, great collections named merely "by sight," but collections actually made in the first place simply because people knew that Merrill would name them. And because of his determining of these vast collections they were placed where the plodding taxonomists could get them and polish them. Nor did he stop there, but continued on, stimulating, directing and sometimes working with others on these great collections, as one can see by perusing his bibliography and noting the joint authorships. Many are the institutions in whose history Merrill's name needs major mention for his direct and indirect influence upon their growth.

Merrill's breadth of vision made him see the

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[1]Merrilleana; a selection from the general writings of Elmer Drew Merrill, Sc.D., LL.D. Chronica Botanica 10(3/4): 131–393. 6 *illus.* 1946.

[2]E. D. Merrill—Autobiographical: Early years, the Philippines, California. Asa Gray Bulletin N. S. 2(3/4): 335–370. 5 *f.* 1953.

need for clearing up confusion in older, neglected but fundamental works. He interpreted the basic works by Blanco, Loureiro, Rafinesque, and others. He sought new collections to stand in place of important old ones no longer existing or lost. He instituted great improvements in various herbaria and seized the opportunities which fell across his path to carry on these programs. Most noteworthy of these opportunities, so far as I am aware, was the Works Progress Administration project, born of the depression in the early '30's and designed to give useful work to the unemployed. Nor did he seize this opportunity just for himself and the organization of which he was by then the Director, the New York Botanical Garden. His typists, whom he had literally by the dozen, made carbons of the original and critical descriptions, which they copied at his direction from otherwise unduplicated literature. Extra copies of these he sent to other institutions, even though at first they were often not warmly received. He realized what the WPA workers could do for the prodigious drudgery of bibliographic work and assigned the best of his staff to our joint "Bibliography of Eastern Asiatic Botany." This work is a monument to his vision and to the many devoted WPA workers whom he selected and inspired by his tirelessness and his confidence in their ability to do the job well.

I think no undertaking exemplifies his breadth of vision more than his acquisition and distribution of seeds of the now widely known *Metasequoia* from interior China. His limited funds were spent, not to take him to the haunts of this newly found "living fossil," but to enable trusted Chinese collectors to go, unencumbered by accompanying foreigners, to gather a generous supply of seeds. These were sent to Dr. Merrill, then Director of the Arnold Arboretum and Administrator of Botanical Collections at Harvard University. He distributed the seeds to institutions the world over, wherever he thought there was a chance they would be planted and cared for. Thus were determined by one extensive experiment the optimum conditions, and the range of possibilities for the growth of this most interesting remnant from the past.

Naturally Merrill left much unfinished. His sizeable book on Cook's voyages was his last finished contribution. It contains much of his distinctive and forceful philosophy, colored, as is to be expected, by the circumstances of his condition and time of life. His belief in immortality was his confidence in the enduring worth of the foundations he had laid down and the ability of others to build thereon. I take strength from the confidence expressed in his turning over to Dr. F. R. Fosberg and me his papers and interest in an eventual fourth edition of the Pacific bibliography.

Dr. Merrill's influence on botany is not ended; it continues through me and many other "Merrill-men," a designation I cherish. He wrote and worked tirelessly for his chosen subject, broadly interpreted in time and space.

Egbert H. Walker

News Notes

Ninth Pacific Science Congress

The Ninth Pacific Science Congress of the Pacific Science Association will take place in Bangkok, November 18 to December 9, 1957. It is being held under the auspices of His Majesty's Government of Thailand and the Science Society of Thailand.

Secretary-General of the Congress is Dr. Charng Ratanarat, Department of Science, Ministry of Industry, Bangkok, Thailand.

Present plans call for organization of the Congress into these divisions: Geology and Geophysics, Meteorology, Oceanography, Fisheries, Zoology, Entomology, Botany, Conservation, Museums, Soil and Land Classification, Forest Resources, Crop Improvement, Coconut Problems, Animal Improvement, Chemistry in the Development of Natural Resources, Anthropology and Social Sciences, Public Health and Medical Sciences, and Nutrition. — Pacific Science Association, Information Bulletin.

Pacific Radiocarbon Dates

An article in *Science* (124:3224, 12 Oct. 1956) presents the first set of radiocarbon dates released by Professor H. R. Crane of the University of Michigan Radiocarbon Dating Laboratory. Pacific dates include a series from Japan, Korea, China, and Manchuria, as well as from Pacific islands.

For the Pacific islands, there is a series of nine dates from materials collected for the University of California expedition, 1952, by E. W. Gifford and Dick Shutler, Jr., from New Caledonia. This is the greatest number of dates covering the longest cultural time-span that has been obtained for any Pacific island. The terminal dates are 2800 $\pm$ 350, and 615 $\pm$ 300. The oldest date, circa 844 B. C., is the earliest radiocarbon date for man in Melanesia.

The New Caledonians speak a Malayo-Polynesian language. As the linguistic relations of New Caledonian and other M-P languages in Polynesia and Melanesia are presently being worked on, it is hoped that through the method of glottochronology and the radiocarbon method it will be possible to relate the occupation of New Caledonia to both Polynesia and Melanesia.

For Fiji, (University of California expedition of 1947, E. W. Gifford), there are six dates, of which the oldest is 2000 $\pm$ 500.

For purposes of comparison, the earliest radiocarbon date for man in the Hawaiian islands is A. D. 1004 $\pm$ 180.

This series of radiocarbon dates marks a major advance in assembling a series of dates for Oceania adequate to establish the temporal framework for the human occupation of the area.—Pacific Science Association, Information Bulletin.

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CRAWFORD, DAVID L. 1920*a*. New or interesting Psyllidae of the Pacific Coast (Homop.). *Ent. News* 31 (1): 12–14.

——— 1920*b*. Cerotrioza (Psyllidae, Homoptera). *Hawaii. Ent. Soc., Proc.* 4 (2): 374–375.

ROCK, JOSEPH F. 1916. The sandalwoods of Hawaii; a revision of the Hawaiian species of the genus *Santalum. Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry Bot., Bul.* 3: 1–43, 13 pls.

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VOL. XI APRIL 1957 NO. 2

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Dumbleton — *New Zealand Aleyrodidae* • Wilson — *Taxonomy of the Genus* Eugenia *in Hawaii* • Palmer — *Origin and Diffusion of the Herzberg Principle* • Banner — *Alpheid Shrimp of Arno Atoll* • Carlquist — *Systematic Anatomy of* Hesperomannia • Reish — *Life History of* Neanthes caudata • Boden and Kampa — *Records of Bioluminescence in the Ocean* • de Laubenfels — *New Species and Records of Hawaiian Sponges*

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(Continued on inside back cover)

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A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

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The New Zealand Aleyrodidae (Hemiptera: Homoptera)[1]

L. J. Dumbleton[2]

The pioneer worker on the New Zealand Aleyrodidae was W. M. Maskell, who also described species from all over the world. The Maskell collection of Aleyrodidae is therefore an important one. It has recently been returned to New Zealand after having been on loan to the Bureau of Entomology of the United States Department of Agriculture for many years and is now, together with the equally important Maskell collection of Coccidae, in the collection of the Entomological Research Station of the Department of Scientific and Industrial Research at Nelson.

It is desirable that Maskell's species should be redescribed. This task has been facilitated by the location of Maskell's unmounted duplicate material of some species and the collection of others from the field. In addition to Maskell's species there is one New Zealand species described by Takahashi (1937). Two species are described as new.

Considerable confusion has centered around Maskell's genus *Asterochiton*, though this has been clarified, in so far as it affects the genus *Trialeurodes*, by Russell (1948).

Maskell (1879) described the first Aleyrodids from New Zealand. These were *lecanioides* (which has page precedence) and *aureus*, for which two species he created a new genus *Asterochiton*, placing it in error as a Coccid genus. No genotype was designated and it is doubtful if his definition of the genus, "characterised by enclosure in a test," is an adequate generic prescription. The figure and description of *aureus* is quite recognisable, while that of *lecanioides* suggests *Trialeurodes vaporariorum* Westw. Maskell (1880) recognised his error and removed his two species of *Asterochiton* from the Coccidae to the Aleyrodidae. In 1890 (pp. 175–176) he repeats the correction and, apparently considering that the genus *Asterochiton* was invalidated or unnecessary, discontinued its use in favour of *Aleurodes*. The species *lecanioides* he stated to have been based on material containing two species, which he now described as *Aleyrodes papillifer* and *A. simplex*. The name *lecanioides* should have remained valid in reference to the *vaporariorum*-like species which he first described. Apparently considering that the invalidation of the genus *Asterochiton* also invalidated the species *aureus* he discarded this name and redescribed and named the same species as *Aleurodes melicyti*. In the same year he described *Aleurodes asplenii* and *A. fagi*. In 1896 he described *A. cerata* and *A. fodiens*.

Cockerell (1902) listed Maskell's species and stated that *papillifer* was a synonym of *lecanioides* and *melicyti* was a synonym of *aureus*. He revived Maskell's name *Asterochiton* as a subgenus of *Aleyrodes*, defined the subgenus, and cited *aureus* as the genotype. He also stated that *lecanioides* did not belong to the subgenus *Asterochiton* as defined by him. He defined the subgenus *Trialeurodes* and nominated *pergandei* Quaintance as the genotype.

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[1] Work performed, in part, while a member of the Entomological Research Station, D.S.I.R., Nelson. Manuscript received February 8, 1956.

[2] Canterbury Agricultural College, Christchurch, New Zealand.

Kirkaldy (1907) gave *Asterochiton* Maskell as a subgenus of *Aleyrodes* and cited *lecanioides* as genotype, stating that Cockerell was wrong in citing *aureus* as genotype.

Quaintance (1908) gave *Asterochiton* Cockerell as a subgenus of *Aleyrodes*, with *aureus* Maskell as genotype, and listed *melicyti* Maskell as a synonym of *aureus* and *papillifer* Maskell as a synonym of *lecanioides* Maskell.

Quaintance and Baker, who published three papers on the classification of the Aleyrodidae, had Maskell's type material available for study. In the 1914 paper (p. 109) *vaporariorum* Westw., of which *lecanioides* Mask. and *papillifer* Mask. are listed as synonyms, is given as the genotype of *Asterochiton* Maskell because these authors wrongly believed Maskell to have designated *lecanioides* as the genotype of *Asterochiton* and, on examination of the type of *papillifer*, found it to be a synonym of *vaporariorum* Westw. Quaintance and Baker (1914: 98), overlooking the fact that Cockerell had designated *aureus* as the genotype of *Asterochiton*, erected a new genus *Dialeurodoides* with *aureus*, which they figured, as genotype, and included in it *fagi* Mask. and *simplex* Mask. In a correction (1915: xi) it was stated that *Asterochiton* of the 1914 paper must replace *Dialeurodoides* Q. and B., and that *Trialeurodes* Cockerell must replace *Asterochiton*. Cockerell's designation of genotypes has priority over those of Kirkaldy (1907) and Quaintance and Baker (1914) and the species congeneric with *aureus* belong to *Asterochiton* Maskell and those congeneric with *pergandei* belong to *Trialeurodes* Cockerell. Quaintance and Baker in the 1914 paper, as amended by the 1915 correction, placed *fodiens* Mask. in *Dialeurodes* and *asplenii* Mask. in *Trialeurodes*. Quaintance and Baker (1917) redescribed and figured *Dialeurodes fodiens* Mask.

Takahashi (1937) described and figured *Aleyrodes winterae*.

The New Zealand Aleyrodid fauna, as it is known at present, is a limited and fairly homogenous one in which only the subfamily Aleyrodinae is represented. The subfamily Udamoselinae is represented in Australia, and Maskell described a species of *Aleurodicus* from Fiji, though it is possibly introduced. The New Zealand fauna shows no obvious affinities with the much larger and more generically diversified fauna of Australia, with that of New Caledonia, or with the limited faunas described from Chile and the insular Pacific region.

Subfamily *ALEYRODINAE* Enderlein

GENERIC KEY TO PUPAL CASES OF NEW ZEALAND SPECIES

1. Numerous papillae in single row on submargin, lingula knobbed and lobed. **Trialeurodes** Cockerell

   Not as above 2

2. Thoracic and abdominal pore areas invaginated, tracheal comb teeth present. . . . . **Asterochiton** Maskell

   Not as above 3

3. With marginal or submarginal setae, caudal furrow absent. . . . **Aleyrodes** Latreille

   Not as above . . . . **Aleuroclava** Singh

KEY TO ADULTS OF NEW ZEALAND SPECIES OF *Aleyrodidae*

1. Antenna with segment 7 twice as long as 6; hind tibiae with comb of 30–34 setae; forewing 1.8 mm. long, R_1 present; lingula widest at apex, truncate, with 4 conical processes. **Asterochiton aureus** Maskell

   Antennal segment 7 not twice as long as 6; hind tibia with not more than 22 setae in comb; wing not longer than 1.5 mm. without R_1 or with stub only; lingula if truncate without apical processes and widest before apex 2

2. Penis in lateral view subparallel sided. . 3

   Penis tapering 6

3. Penis narrow, strongly sinuate, apex truncate; wing with stub of R_1 present; lingula truncate, excised at corners of apex. . . . . **Aleuroclava eucalypti** n. sp.
Penis wide, not sinuate, apex toothed; lingula rounded apically 4
4. Apical tooth of penis longer, more pointed; antennal segment 5 nearly twice as long as 6 . . . . **Aleyrodes fodiens** Maskell
Apical tooth of penis shorter, more rounded; antennal segment 5 slightly longer than 6 5
5. Apex of penis narrowed abruptly at nearly right angles, to base of apical tooth . . . . **Asterochiton pittospori** n. sp.
Apex of penis narrowed obliquely at 45 degrees, to base of tooth . . . . **Asterochiton simplex** (Maskell)
6. Penis more strongly hooked or falcate apically; antennal segment 3 longer than 4–6 combined; wing length 1.5 mm.; lingula truncate apically . . . . **Trialeurodes asplenii** (Maskell)
Penis apex less strongly hooked; antennal segment 3 shorter than 4–6 combined; wing length 1.0 mm.; lingula truncate-excavate apically . . . . **Trialeurodes vaporariorum** (Westw.)

Genus Trialeurodes Cockerell

KEY TO PUPAL CASES OF NEW ZEALAND SPECIES OF *Trialeurodes*

With up to 7 larger, circular papillae on the submargin in addition to the more numerous smaller conical papillae; unpigmented in median areas . . . . **vaporariorum** (Westw.)
Submarginal papillae uniform in size; pigmented on cephalic and abdominal median areas . . . . **asplenii** (Maskell)

Trialeurodes asplenii (Maskell)
Figs. 1, 2

Aleurodes asplenii Maskell 1890: 173–4, pl. 13, figs. 18–20.

Aleyrodes asplenii Maskell. Cockerell, 1902: 281; Kirkaldy, 1907: 46; Quaintance, 1908: 5.

Asterochiton asplenii (Mask.) Quaintance and Baker, 1914: 105, and footnote p. 104.

Trialeurodes asplenii (Mask.) Quaintance and Baker, 1915: xi.

LARVA: Described by Maskell (1890: 174, fig. 18). Specimen not located.

PUPAL CASE: (Fig. 1). Length 1.0 mm., width 0.7 mm. Derm pale but with light brown pigmentation in the median cephalic area and in the median and subdorsal area of abdominal segments 2–6 inclusive. Elliptical, widest behind mid-length, raised on vertical white wax palisade. Margin crenulated, about 20 crenulations in 0.1 mm. Thoracic tracheal fold present. Tracheal pore (Fig. 2*a*) semicircular, with 4–5 marginal crenulations opposite the pore narrower than the others. Abdominal tracheal fold and pore absent, crenulations not noticeably narrower. Submarginal area with a single row of about 55 fairly sharply conical papillae of uniform size on each side. Abdominal segment 7 not as narrow as in *vaporariorum*. Subdorsal papillae absent. One pair of para-median cephalic setae, one pair on each of first and 8th abdominal segments and one pair of caudal setae (Fig. 2*b*). Posterior marginal setae present. Vasiform orifice (Fig. 2*c*) subcordate, notched posteriorly, length 0.085 mm., width 0.06 mm. Operculum occupying about half the orifice, length 0.04 mm., width 0.05 mm. Lingula clubbed, with three paired lateral lobes and one unpaired median caudal lobe and two apical setae. Caudal furrow absent.

ADULT: (Fig. 2*d*, *e*). *Female*, antennae with segment 3 longer than segments 4–6 combined, segments 4 and 6 subequal and shorter than 5 and 7, 5 longer than 7, flagellum of 7 much shorter than base. Wings white, immaculate, forewing length 1.5 mm. Hind tibia with about 16 setae in comb. *Male*, operculum (Fig. 2*d*) transverse, 0.02 mm. long, 0.04 mm. wide, posterior margin concave. Lingula

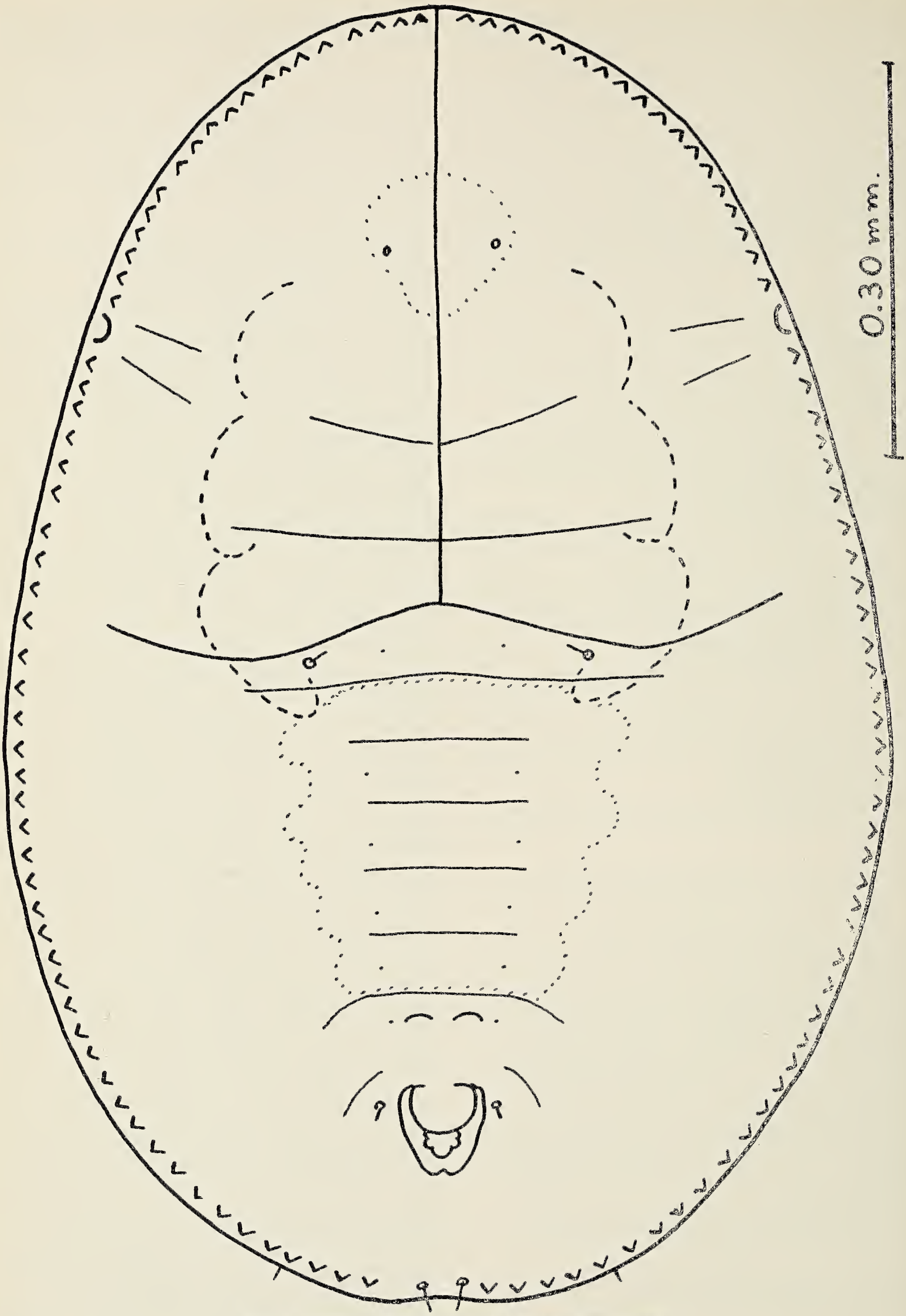

FIG. 1. *Trialeurodes asplenii* Mask. Pupal case, dorsal.

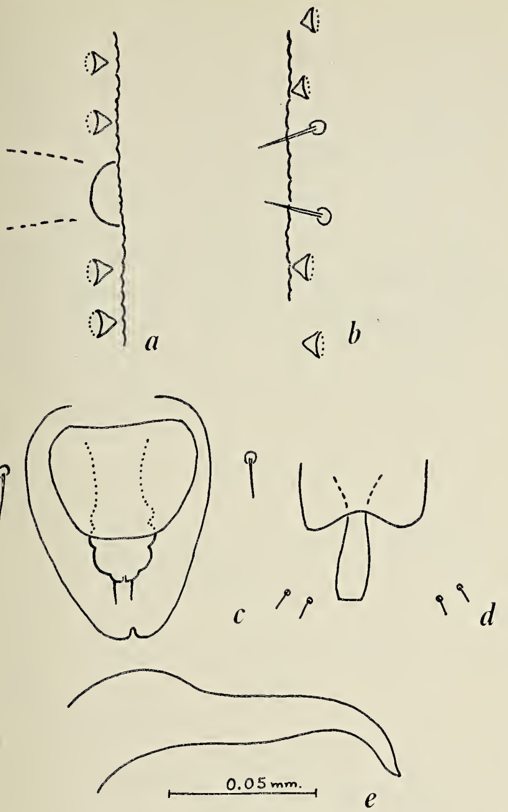

FIG. 2. *Trialeurodes asplenii* Mask. Pupal case: *a*, Thoracic tracheal fold and pore; *b*, caudal margin; *c*, vasiform orifice. Adult male: *d*, Operculum and lingula; *e*, penis, lateral view.

about 0.04 mm. long, 0.01 mm. wide, constricted near base, truncate apically. Penis (Fig. 2*e*) tapered to apex which is pointed not truncate and curved dorsally. Slightly sinuate above and below, length 0.11 mm.

LECTOTYPE: Pupal case on slide mount. Maskell collection.

TYPE LOCALITY: New Zealand.

FOOD PLANT: Fern, *Asplenium lucidum* and other ferns.

COTYPE: Pupal case on slide mount, U. S. Bureau of Entomology.

OTHER MATERIAL: Slide mounts of genitalia and wings and unmounted duplicate material in Maskell collection. Unmounted duplicate material (3 pupae and one larva) in U. S. Bureau of Entomology. Pupal cases and adults from *Asplenium lucidum*, Ruby Bay, Nelson, Jan. 1952, in the author's collection.

There are no undoubtedly endemic species of *Trialeurodes* known in Australia or New Zealand and since *asplenii* occurs on *Asplenium* and other ferns it could well have been introduced on ornamental ferns and not be native to New Zealand.

Trialeurodes vaporariorum (Westwood)
Figs. 3–5

Aleyrodes vaporariorum Westw. 1856. Gardeners Chronicle, p. 852.
Asterochiton lecanioides Maskell, 1879: 215–216 (in part), 1880: 300–301 (in part); Quaintance and Baker, 1914: 105.
Aleyrodes lecanioides (Mask.). Cockerell, 1902: 281; Kirkaldy, 1907: 60.
Aleurodes papillifer Maskell, 1890: 173, 1896: 438.
Asterochiton papillifer (Mask.). Quaintance and Baker, 1914: 105.
Trialeurodes lecanioides (Mask.). Quaintance and Baker, 1915: 11; Russell, 1948: 7–8, 43–45.
Trialeurodes papillifer (Mask.). Quaintance and Baker, 1915: 11; Russell, 1948: 7–8, 43–45.

PUPAL CASE: (Fig. 3). Length 0.75–0.10 mm., width 0.5–0.75 mm. Derm thin and colourless except for the papillae. Shape elliptical. Case raised off leaf on vertical palisade of white wax. Margin (Fig. 4*a*) crenulated, about 12 crenulations in 0.1 mm. Thoracic tracheal pore area (Fig. 4*b*) marked by narrowing and depth of 3–10 crenulations. Commonly 75–110 submarginal papillae in a single row; 1–9 pairs may be larger than the others but these may be absent. Usually four pairs of subdorsal papillae but these may be absent. When present one pair is cephalic, one pair mesothoracic and one pair on each of the third and fourth abdominal segments. Setae; one pair cephalic, one pair first abdominal, one pair 8th abdominal often very long, and one pair caudal usually long. Vasi-

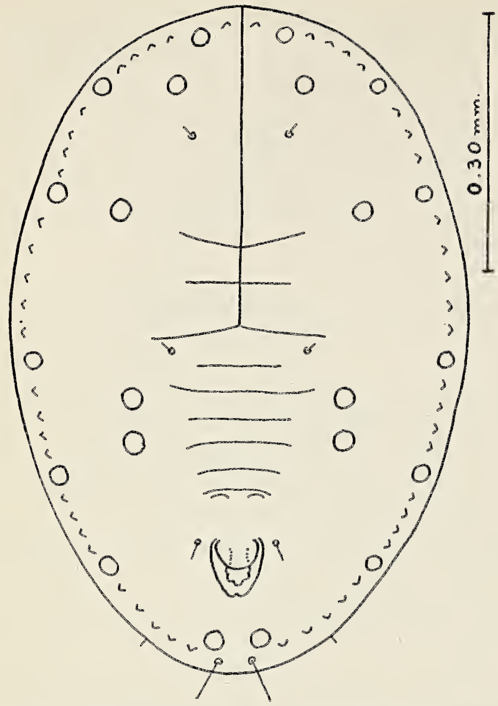

FIG. 3. *Trialeurodes vaporariorum* Westw. Pupal case, dorsal.

form orifice (Fig. 4*c*) 0.056–0.076 mm. long, 0.056–0.070 mm. wide, cordate, notched at posterior tip and with prominent tooth in notch. Operculum 0.036–0.048 mm. long and 0.044–0.060 mm. wide, cordate. Lingula 0.040–0.060 mm. long, 0.024–0.032 mm. wide, with two long setae and three pairs of lateral lobes and one median unpaired lobe. Caudal furrow present narrow.

ADULT: *Female*, antennae (Fig. 5*a*) with segment 3 shorter than segments 4–6 combined, 5 nearly twice as long as 6, flagellum of 7 short. Wings white unspotted, forewing 1.0 mm. long, R_1 absent. Hind tibiae with 13–16 setae in comb. *Male*, operculum (Fig. 5*b*) 0.02 mm. long, 0.045 mm. wide. Lingula truncate and excavate apically, length 0.03 mm., width 0.01 mm. Penis (Fig. 5*c*) length 0.1 mm., tapering and slightly falcate at apex in lateral view.

FOOD PLANTS: Recorded by Maskell from *Pittosporum eugenioides* and *Geniostoma* sp. Common on tomato and other plants.

MATERIAL: A slide of *papillifer* (dated 1889, W. M. M.) stained and remounted by the U. S. Bureau of Entomology in the Maskell collection.

A cosmopolitan species.

Genus ASTEROCHITON Maskell

The generic prescription of Quaintance and Baker (1914: 98) and Sampson (1943: 208) must be amended as follows:

Medium in size, subelliptical to sub-

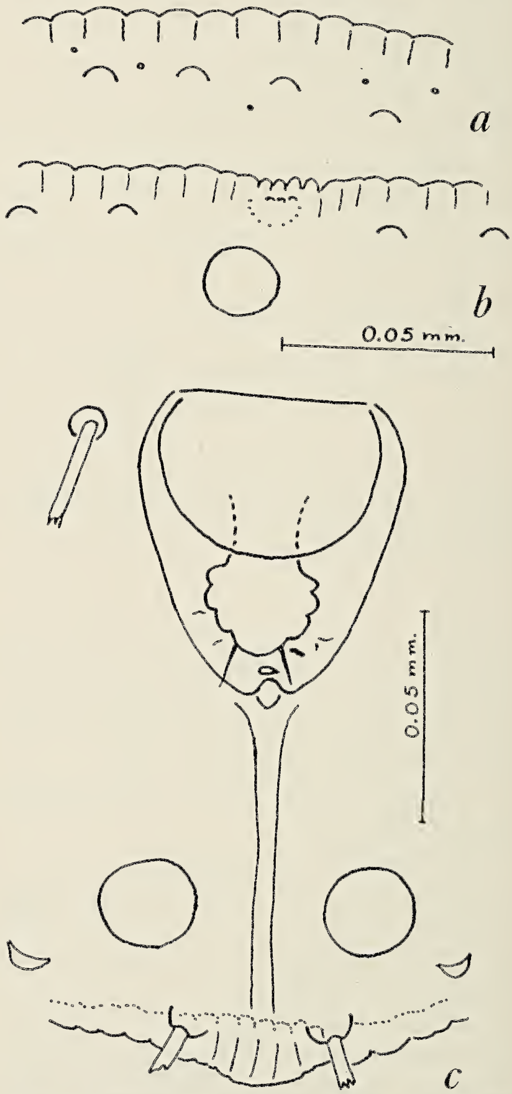

FIG. 4. *Trialeurodes vaporariorum* Westw. Pupal case: *a*, Margin; *b*, thoracic tracheal pore; *c*, vasiform orifice and caudal margin.

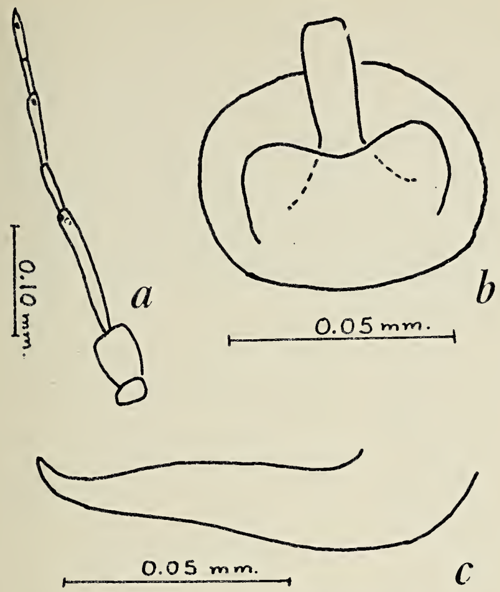

FIG. 5. *Trialeurodes vaporariorum* Westw. Adult female: *a*, Antenna. Adult male: *b*, Vasiform orifice; *c*, penis.

circular in shape. Margin with one row of teeth. Submargin may be separated from dorsal disc. Thoracic tracheal folds and combs present. Caudal fold may be indicated, comb present. Vasiform orifice subcordate, may be pointed posteriorly. Operculum transversely semicircular, subcordate or subtrapezoidal, filling about half the orifice. Lingula expanded at tip, bluntly pointed or rounded, exposed, included.

KEY TO PUPAL CASES OF NEW ZEALAND SPECIES OF *Asterochiton*

1. With four prominent radial pore bands on disc; pores present on submargin....... .... **aureus** Maskell

   Not as above.......................2
2. With 13 prominent submarginal setae on each side............... **fagi** (Maskell)

   Not as above.......................3
3. Without discal setae; submargin defined .... **cerata** (Maskell)

   Not as above.......................4
4. Abdomen with 4 pairs of setae laterad on disc on segments 5–8 . **simplex** (Maskell)

   Abdomen with only one pair of setae laterad on disc, on segment 4.......... .... **pittospori** n. sp.

Asterochiton aureus Maskell
Figs. 6–8

Asterochiton aureus Maskell. 1879: 216, pl. 7, fig. 17d; 1881: 301.
Aleurodes melicyti Maskell. 1890: 174, pl. 13, figs. 21–24.
Aleyrodes (*Asterochiton*) *aurea* (Mask.) Cockerell, 1902: 282.
Aleyrodes (*Asterochiton*) *aureus* (Mask.) Kirkaldy, 1907: 47; Quaintance, 1908: 5.
Dialeurodoides aureus (Mask.) Quaintance and Baker, 1914, pp. 98–99, pl. 37, figs. 7–11.
Asterochiton aureus (Mask.) Quaintance and Baker, 1915, p. xi; Sampson, 1943: 208; Russell, 1948: 7–8.

PUPAL CASE: (Fig. 6). Length 1.1 mm., width 1.0 mm. Colour golden yellow, pale brown in median area. Shape subcircular. Margin (Fig. 7*a*) irregularly toothed, about 10 teeth in 0.10 mm. The teeth do not appear to constitute the actual margin which is clear and straight. Thoracic tracheal fold (Fig. 7*b*) distinct, pore abruptly invaginated and with comb of 3–6 teeth. Abdominal tracheal pore (Fig. 7*c*) similar. Setae: posterior marginal, caudal and 8th abdominal setae present. Submarginal area 0.045 mm. wide with numerous large pores and separated by a line mesad of the pores from the dorsal disc. Similar pores are present on the anterior cephalic area of the disc before the cephalic ridge and a few on either side of the caudal furrow. On the disc are four radiating rows of similar pores, two immediately above the thoracic tracheal folds and two on the abdomen just caudad of the transverse moulting suture. The location of the smaller simple pores is shown in the figure. On the cephalic region are two paramedian transverse ridges on each of which are three or four simple pores. Above the

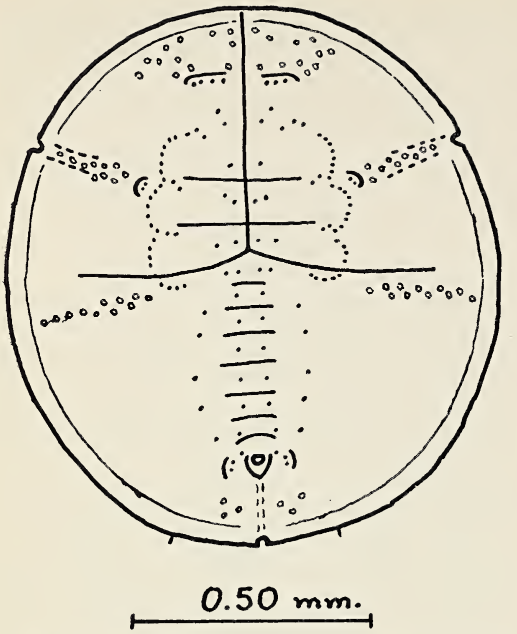

FIG. 6. *Asterochiton aureus* Mask. Pupal case, dorsal.

inner ends of the thoracic folds is a tubercle bearing 2 or 3 simple pores. The vasiform orifice (Fig. 7*c*) is subtriangular 0.06 mm. long and 0.057 mm. wide and acute posteriorly. Operculum is semicircular with a concave anterior margin, 0.04 mm. wide and 0.027 mm. long. The lingula is long; exposed apically and pointed but not acutely so. The floor of the orifice is reticulate. Neither the lingula nor the posterior apex of the orifice is as pointed as is figured by Quaintance and Baker (1914). Caudal furrow present, narrow.

Parasitised pupae are convex, with a narrow glassy white wax ring which is sloping and not vertical. There are white marks in this rim opposite the tracheal pores. The pupa is dark brown to black in the central disc with golden brown margins. There are strong radial ridges coinciding with the four radial pore bands and fainter ridges from each side of the cephalic ridge to the margin and from each side of the orifice to the margin.

ADULT: *Female*, antennae: segment 3, 0.23 mm.; 4, 0.06; 5, 0.07; 6, 0.05; 7, 0.11 mm. long; base of 7 is about ¾ the total length. Wings white immaculate, forewing (Fig. 8*a*) 1.8 mm. long, R_1 present. Hind tibiae (Fig. 8*b*) with 30–34 setae in comb. Operculum (Fig. 8*c*) excised posteriorly with two setae on posterior margin, width 0.04 mm., length 0.025 mm. Lingula widening to apex, truncate, lobed at each posterior lateral angle and with two conical processes between these with apical setae. Lingula length 0.035 mm., width 0.01 mm.

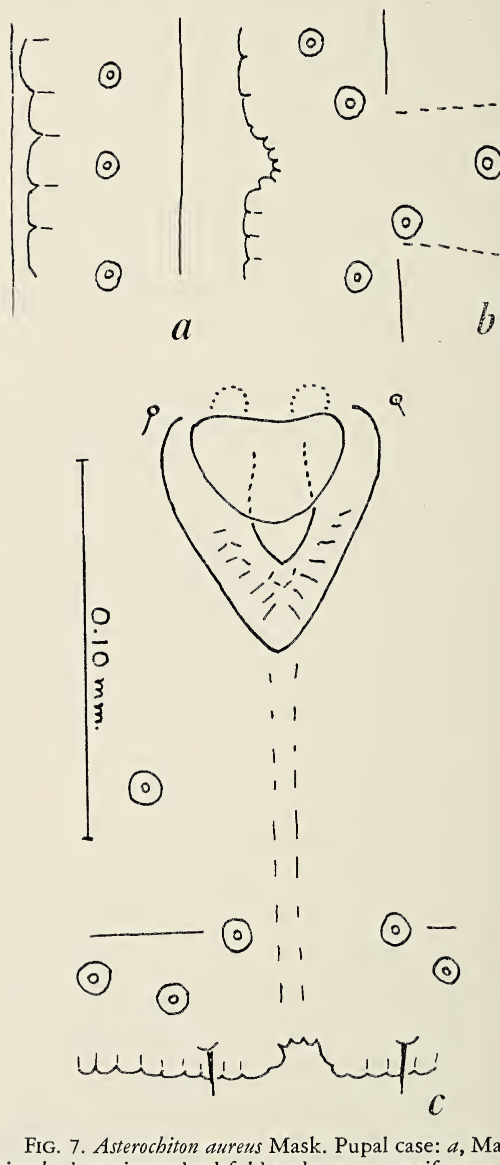

FIG. 7. *Asterochiton aureus* Mask. Pupal case: *a*, Margin; *b*, thoracic tracheal fold and pore; *c*, vasiform orifice and abdominal tracheal pore.

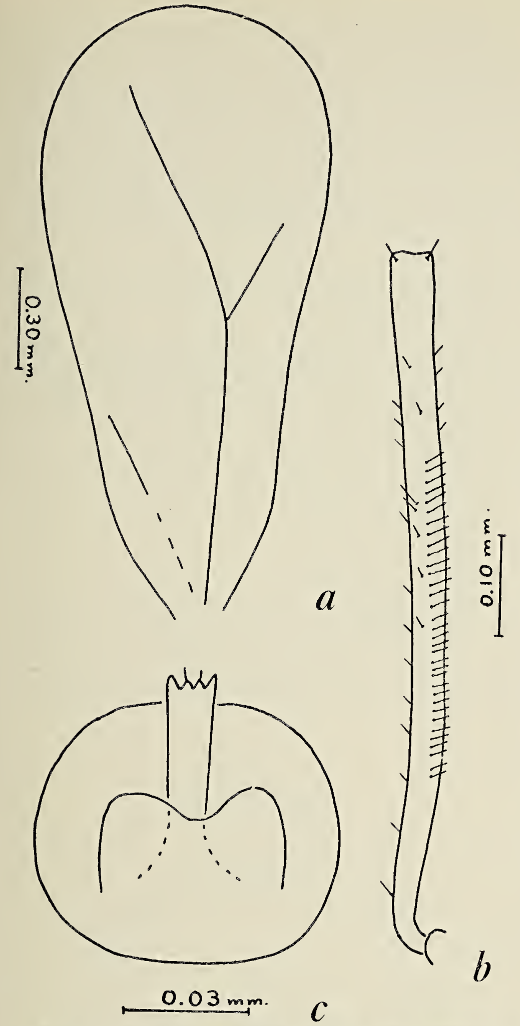

FIG. 8. *Asterochiton aureus* Mask. Adult female: *a*, Forewing; *b*, hind tibia; *c*, vasiform orifice.

LECTOTYPE: Pupal case on slide mount in Maskell collection (labelled *melicyti*).

FOOD PLANT: *Melicytus ramiflorus* (W.M.M.).

TYPE LOCALITY: Auckland.

MATERIAL: One pupal case on cardboard (Maskell material of *melicyti*) in U. S. Bureau of Entomology. Five pupal cases on one slide mount (labelled *melicyti* by Maskell, 1878) in the Canterbury Museum.

Adult females and pupal cases were collected from *Melicytus ramiflorus* at Ruby Bay, Nelson, in January 1952. The pupal cases were sparse and few on a leaf and were dead and mostly parasitised.

Asterochiton cerata (Maskell)

Figs. 9, 10

Aleurodes cerata Maskell 1896: 425–6, pl. 26, fig. 1.

Aleyrodes cerata Mask. Cockerell, 1902: 281; Kirkaldy, 1907: 49; Quaintance, 1908: 5; Quaintance and Baker, 1914: 100.

LARVA: Described by Maskell (1896: 425). Specimen missing.

PUPAL CASE: (Fig. 9). Length 1.1 mm., width 0.7 mm. Shape elliptical flat. Dorsum covered with white flocculent wax, and a narrow ring of clear wax remains on leaf when case is removed. Colour yellowish-brown. Margin irregularly toothed. Thoracic tracheal folds not evident, thoracic tracheal pore (Fig. 10*a*) invaginated with comb of 2 or 3 teeth at bottom. Abdominal tracheal folds not evident, pore (Fig. 10*b*) and comb similar to thoracic. Setae: 8th abdominal, caudal and posterior marginal setae present. Submargin 0.03 mm. wide, delimited by line immediately mesad of which is a row of about 12 minute setae on each half and mesad of these a row of 60–65 minute circular pores. Sutures and segmentation faint. Pairs of faint paramedian pores on abdominal segments 1–7. Vasiform

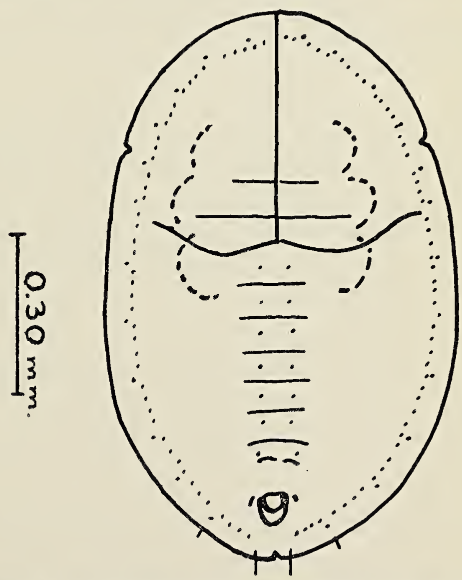

FIG. 9. *Asterochiton cerata* Mask. Pupal case, dorsal.

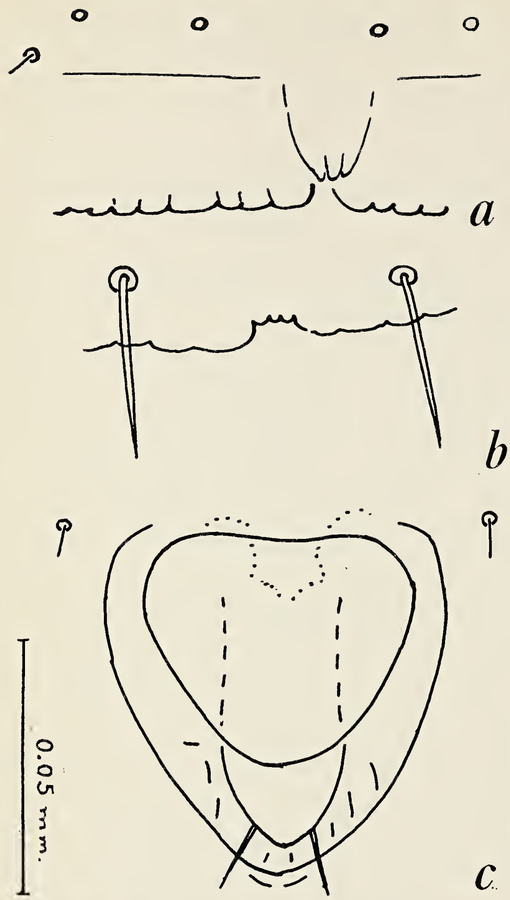

FIG. 10. *Asterochiton cerata* Mask. Pupal case: *a*, Thoracic tracheal pore; *b*, abdominal tracheal pore; *c*, vasiform orifice.

orifice (Fig. 10*c*) subcordate, 0.07 mm. long, 0.065 mm. wide, floor reticulate. Operculum subtriangular, 0.04 mm. long, 0.05 mm. wide more than half filling orifice. Lingula little constricted basally, bluntly pointed, with two strong apical setae.

ADULT: Unknown.

LECTOTYPE: Slide mount of pupal case (labelled larva) in Maskell collection.

FOOD PLANT: *Nothofagus menziesii.*

TYPE LOCALITY: Reefton. Collect. R. Raithby.

MATERIAL: One pupal case on Maskell slide mount (cotype) in U. S. Bureau of Entomology.

Duplicate unmounted material in Maskell collection. This species, which is not a typical *Aleurodes* but has the facies of *Asterochiton*, has been transferred by me to that genus.

Asterochiton fagi (Maskell)
Figs. 11, 12

Aleurodes fagi Maskell, 1890: 175, pl. 13, figs. 25, 26; 1896: 432.

Aleyrodes fagi Mask. Cockerell, 1902: 281; Kirkaldy, 1907: 53; Quaintance, 1908: 6.

Dialeurodoides fagi (Mask.) Quaintance and Baker, 1914: 99.

Asterochiton fagi (Mask.) Quaintance and Baker, 1915: xi.

LARVA: Unknown.

PUPAL CASE: (Fig. 11). Length 1.2 mm. Width 0.90 mm. Colour light yellowish-brown. Shape elliptical. Raised on vertical palisade of wax. Margin (Fig. 12*a*) irregularly

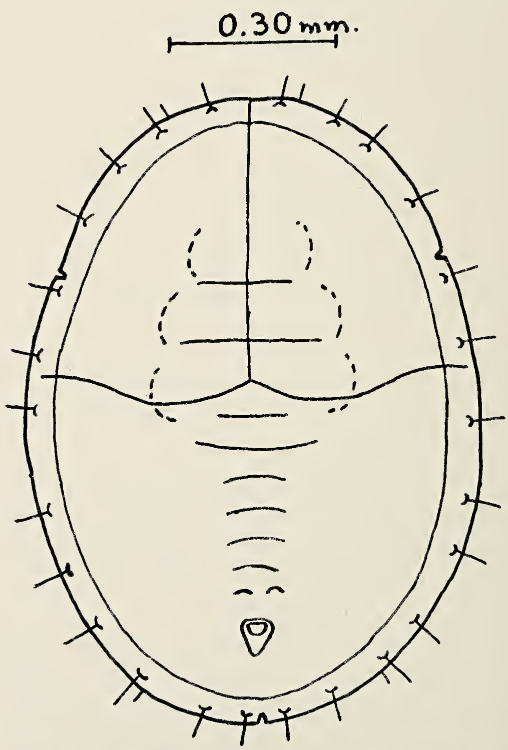

FIG. 11. *Asterochiton fagi* Mask. Pupal case, dorsal.

crenulate. Tracheal folds not evident. Thoracic tracheal pore (Fig. 12*b*) invaginated with two or three small teeth at bottom. Abdominal tracheal pore (Fig. 12*c*) similar. Anterior and posterior marginal setae present. Thirteen submarginal setae 0.10 mm. long on each side, based just mesad of margin, six on cephalothorax and 7 on abdomen. Minute setae on 8th abdominal segment. Caudal setae not differentiated from marginal setae. Disc without setae or prominent pores. Submargin separated from disc by line 0.07 mm. from margin. Vasiform orifice (Fig. 12*d*) 0.08 mm. long, 0.06 mm. wide, subtriangular, rather acute posteriorly. Operculum 0.05 mm. wide, 0.04 mm. long, sub-semicircular. Lingula slightly constricted basally, bluntly pointed apically, with two apical setae.

ADULT: Unknown.

LECTOTYPE: Slide mount of pupal case in Maskell collection.

FOOD PLANT: *Nothofagus menziesii.*

TYPE LOCALITY: Inangahua. collect. R. Raithby.

MATERIAL: One pupal case on leaf (Maskell material) in U. S. Bureau of Entomology. Two pupal cases on leaf in Maskell collection. Unmounted Maskell duplicate material in Maskell collection. All or nearly all the material has been parasitised.

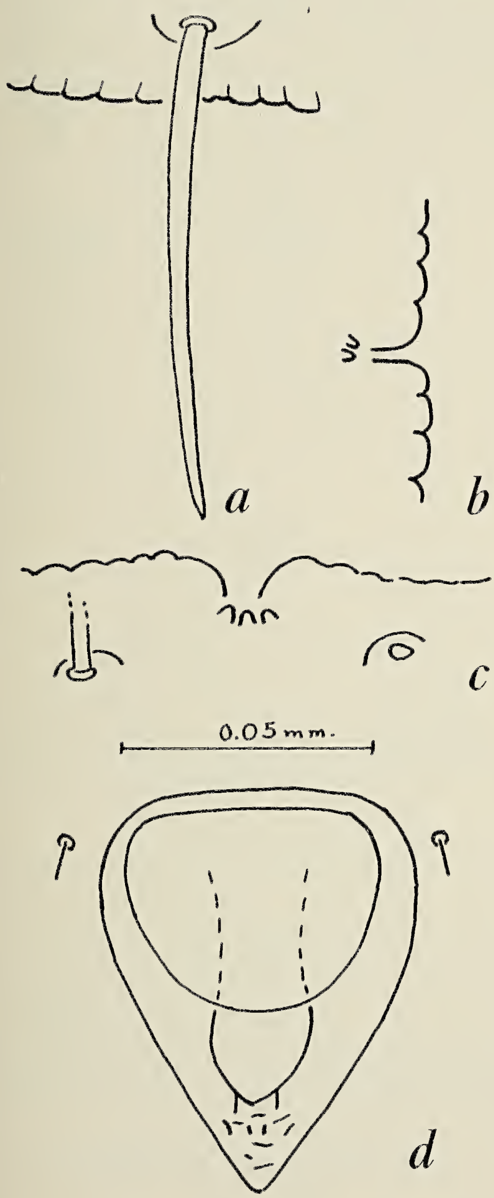

FIG. 12. *Asterochiton fagi* Mask. Pupal case: *a*, Margin; *b*, thoracic tracheal pore; *c*, abdominal tracheal pore; *d*, vasiform orifice.

Asterochiton pittospori n. sp.
Figs. 13–15

LARVA: Unknown.

PUPAL CASE: (Fig. 13). Length 1.3 mm., width 1.0 mm. Colour white. Shape elliptical, flat. With a narrow fringe of white wax. Margin (Fig. 14*a*) is obscurely and rather irregularly toothed or crenulate. Thoracic tracheal fold (Fig. 14*b*) present, pore invaginated with a few or a group of teeth at bottom. Caudal fold absent, pore and comb (Fig. 14*c*) similar to thoracic. Anterior and posterior marginal setae present. Eight cephalothoracic discal setae as in *simplex*, one pair on first abdominal segment, one pair on fourth abdominal segment, one pair of minute setae on 8th abdominal segment and one pair of caudal setae of same size as other discal setae. Vasiform orifice (Fig. 14*d*) subtriangular, 0.7 mm. long, 0.6 mm. wide, floor reticulate. Operculum semicircular 0.05 mm. wide, 0.035 mm. long, half filling orifice. Lingula 0.04 mm.

long, finger-like, rounded apically, slightly constricted basally.

ADULT: *Female*, antenna (Fig. 15*a*) segment 3, 0.17 mm. long; 4, 0.04 mm.; 5, 0.05 mm.; 6, 0.04 mm.; 7, 0.05 mm., flagellum of 7 very short about ¼ as long as base. Wings (Fig. 15*b*) white, immaculate, forewing length 1.4 mm., R_1 absent. Hind tibiae with 22 setae in comb. *Male*, vasiform orifice (Fig. 15*c*) subcircular. Operculum 0.035 mm. wide, 0.015 mm. long, emarginate apically. Lingula finger-like, 0.035 mm. long, 0.009 mm. wide. Clasper (Fig. 15*c*) 0.12 mm. long, acutely pointed, rounded mesally at mid-length. Penis (Fig. 15*d*) in lateral view roundly angled at mid-length, subparallel sided, apically abruptly truncate and with slightly hooked tooth.

HOLOTYPE: Pupal case on slide mount deposited in Maskell collection.

TYPE LOCALITY: Pelorus Bridge. Collect. L. J. D. 20/10/51.

FOOD PLANT: *Pittosporum eugenioides*.

Closely related to *Asterochiton simplex* Maskell from the same food plant.

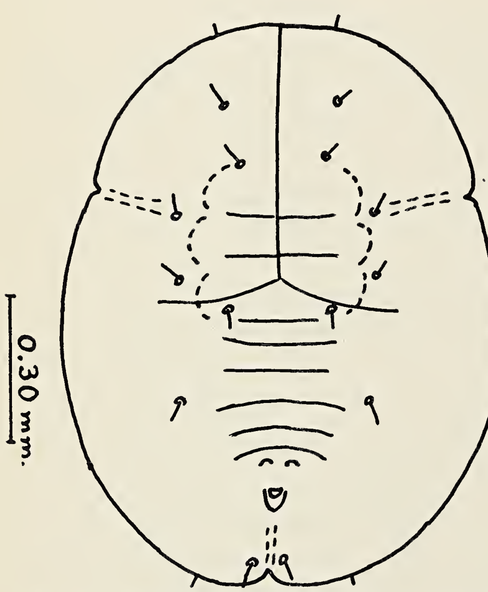

FIG. 13. *Asterochiton pittospori* n. sp. Pupal case, dorsal.

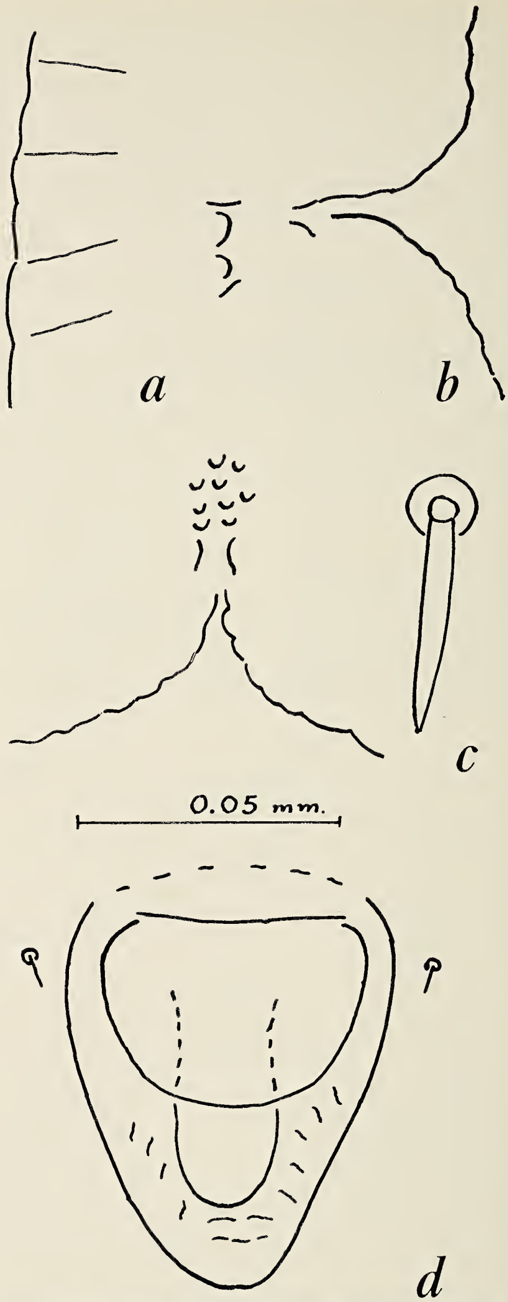

FIG. 14. *Asterochiton pittospori* n. sp. Pupal case: *a*, Margin; *b*, thoracic tracheal pore; *c*, abdominal tracheal pore; *d*, vasiform orifice.

Asterochiton simplex (Maskell)
Figs. 16–18

Asterochiton lecanioides Mask. (in part) 1879: 215–6.

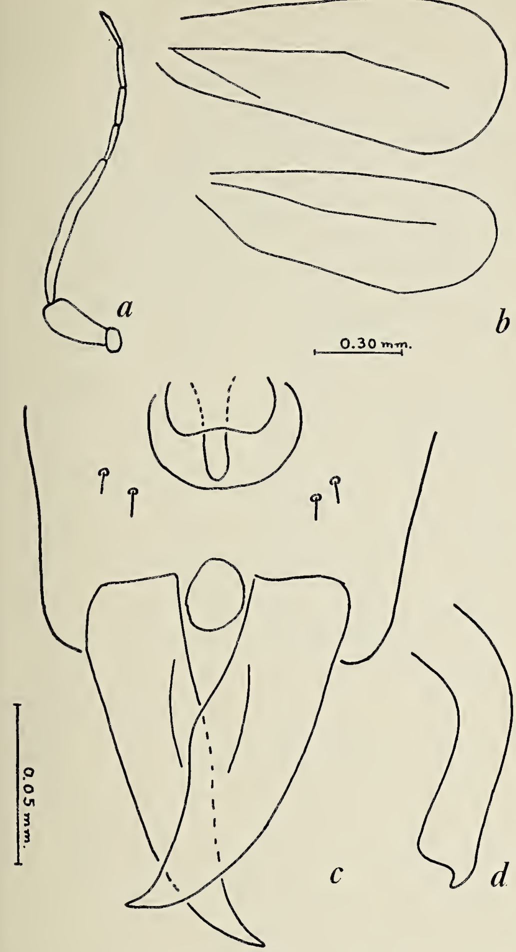

FIG. 15. *Asterochiton pittospori* n. sp. Adult female: *a*, Antenna; *b*, wings. Adult male: *c*, Vasiform orifice and claspers; *d*, penis, lateral view.

Aleurodes simplex Mask., 1890: 175–6, pl. 13, fig. 27; 1896: 441–2.
Aleyrodes simplex Mask. Cockerell, 1902: 281; Kirkaldy, 1907: 69; Quaintance, 1908: 7.
Dialeurodoides simplex (Mask.) Quaintance and Baker, 1914: 99.
Asterochiton simplex (Mask.) Quaintance and Baker, 1915: xi.

LARVA: Unknown.

PUPAL CASE: (Fig. 16). Length 1.2 mm., width 0.90 mm. Colour white. Shape elliptical, flat. With a narrow fringe of white wax. Margin (Fig. 17*a*) regularly crenulate, about 12 crenulations per 0.10 mm. Thoracic tracheal folds present but faint. Tracheal pore (Fig. 17*b*) invaginated with three or four irregular teeth at bottom. Abdominal tracheal fold, pore and comb (Fig. 17*c*) similar to thoracic. Submarginal area not differentiated. Posterior marginal setae present. Four pairs of setae on cephalothorax. One pair of setae on each of first, fourth, fifth, sixth and seventh abdominal segments. A pair of minute setae on 8th. Caudal setae same size as other abdominal setae. Vasiform orifice (Fig. 17*d*) subtriangular, 0.021 mm. long, 0.019 mm. wide, floor reticulate. Operculum subtriangular 0.015 mm. wide, 0.009 mm. long, not filling half orifice. Lingula finger-like, rounded apically, slightly constricted basally. Caudal furrow absent.

ADULT: *Female*, antennae (Fig. 18*a*) segment 1, 0.02 mm. long; 2, 0.06 mm.; 3, 0.165 mm.; 4, 0.03 mm.; remainder missing. Wings,

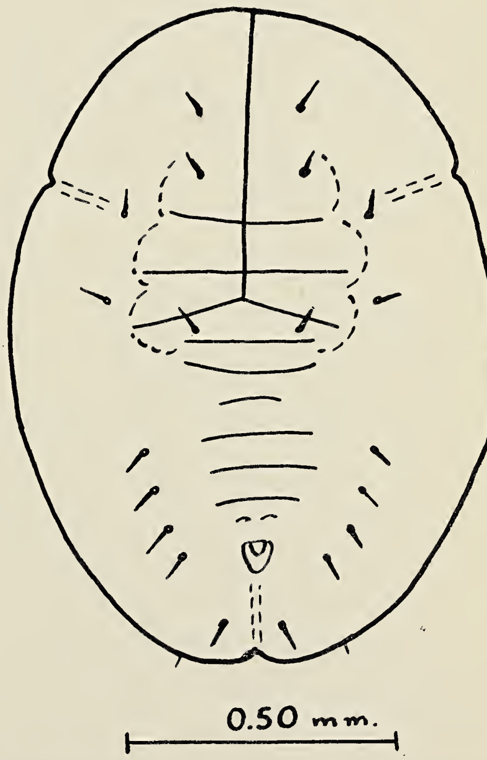

FIG. 16. *Asterochiton simplex* Mask. Pupal case, dorsal.

white, immaculate, forewing (Fig. 18*b*) 1.3 mm. long, R_1 absent. *Male*, vasiform orifice (Fig. 18*c*) subcircular. Operculum transverse, 0.04 mm. wide, 0.02 mm. long, emarginate apically. Lingula 0.03 mm. long, 0.01 mm. wide, finger-like, rounded apically, slightly constricted basally. Clasper (Fig. 18*d*) 0.155 mm. long, acutely pointed and with a slightly rounded hump at mid-length mesally. Penis (Fig. 18*e*) as in figure. Not abruptly truncate but tapering more gradually to base of tooth.

LECTOTYPE: Pupal case on slide mount in Maskell collection.

TYPE LOCALITY: Christchurch.

FOOD PLANTS: *Pittosporum eugenioides*, *Coprosma lucida* and several other trees.

MATERIAL: Two pupal cases (Maskell material) on leaf in U. S. Bureau of Entomology. Pupal material labelled *lecanioides* in Canterbury Museum. Unmounted duplicate material in Maskell collection.

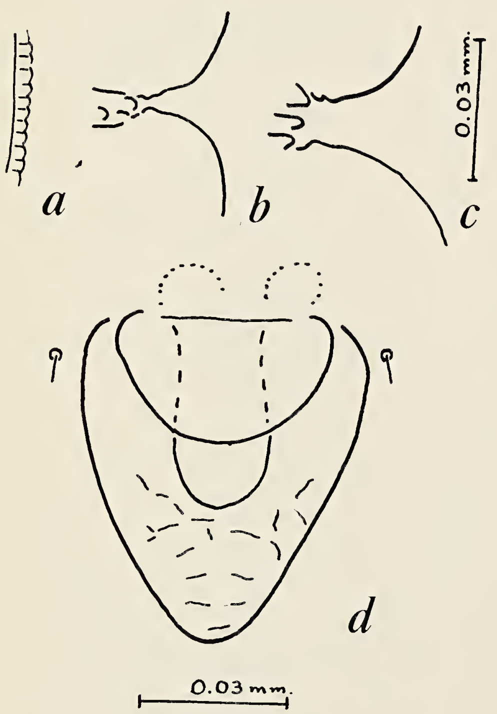

FIG. 17. *Asterochiton simplex* Mask. Pupal case: *a*, Margin; *b*, thoracic tracheal pore; *c*, abdominal tracheal pore; *d*, vasiform orifice.

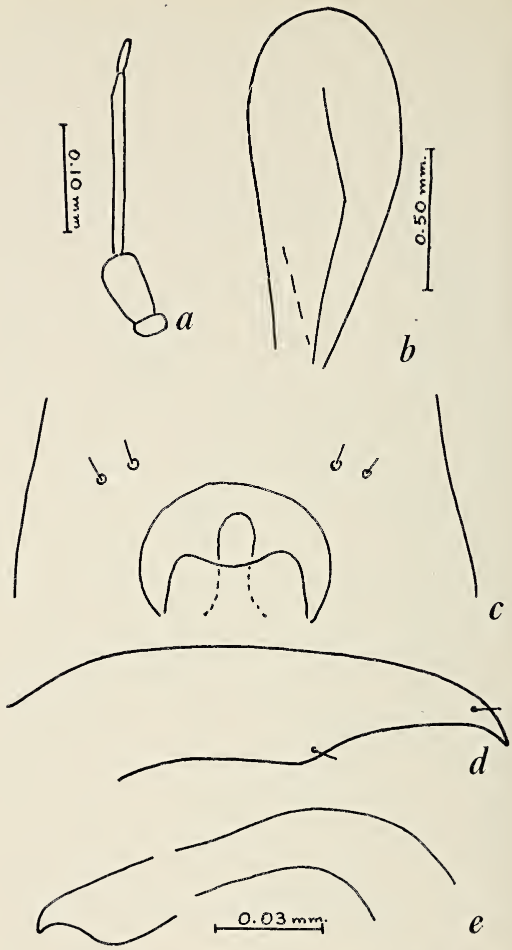

FIG. 18. *Asterochiton simplex* Mask. Adult female: *a*, Antenna; *b*, forewing. Adult male: *c*, Vasiform orifice; *d*, clasper; *e*, penis, lateral view.

Genus ALEYRODES Latreille

KEY TO PUPAL CASES OF NEW ZEALAND SPECIES OF *Aleyrodes*

Subcircular; 14 minute submarginal setae on each side; medial pigmentation light brown .... **fodiens** Maskell

Broadly elliptical; 11 submarginal setae on each side; no pigmentation............... .... **winterae** Takahashi

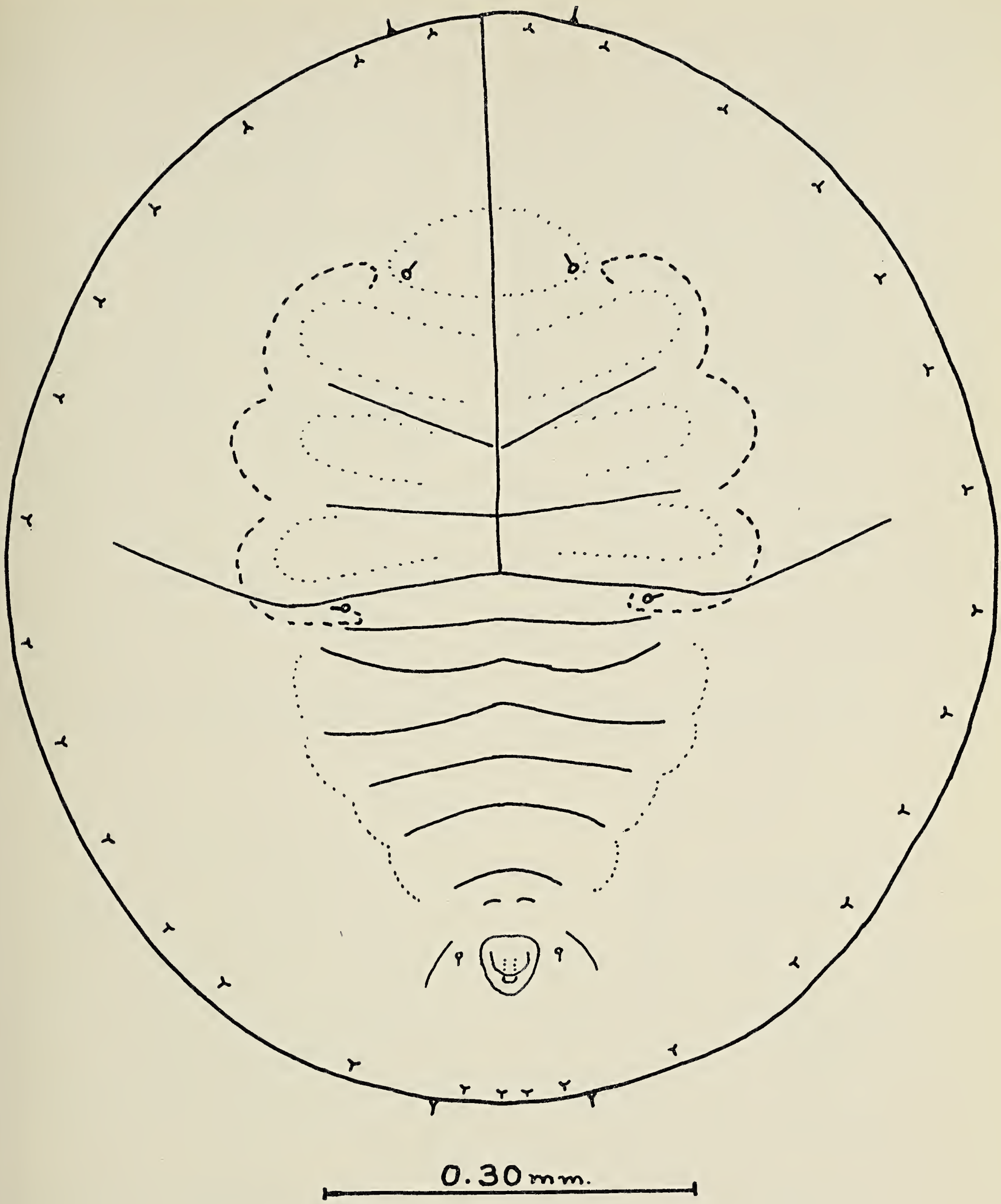

FIG. 19. *Aleyrodes fodiens* Mask. Pupal case, dorsal.

Aleyrodes fodiens (Maskell)
Figs. 19–21

Aleurodes fodiens Mask. 1896: 433–4, pl. 30, fig. 2; (Mask.) Cockerell, 1902: 281.
Aleyrodes fodiens (Mask.) Kirkaldy, 1907: 54; (Mask.) Quaintance 1908: 6.
Dialeurodes fodiens (Mask.) Quaintance and Baker, 1914: 97; Quaintance and Baker, 1917: 407, 415–416, pl. 66, figs. 1–4.

LARVA: Described by Maskell (1896) in

general terms. Slide missing.

PUPAL CASE: (Fig. 19). Length 0.87 mm., width 0.80 mm. Colour light brown in central disc and halfway to margins. Shape subcircular, flat. Margin obscurely and irregularly dentate, about 20 teeth in 0.10 mm. Thoracic and abdominal tracheal folds, pores and combs absent. Anterior and posterior marginal setae present. Fourteen minute submarginal setae on each half just mesad of margin. Submargin not delimited. One pair of minute setae on cephalic area, and on first and eighth abdominal segments. Caudal setae twice as long as marginal setae. Sutures and segmentation as in figure. Vasiform orifice (Fig. 20*a*) 0.062 mm. long, 0.05 mm. wide, subcordate, floor strongly reticulate, almost appearing to be toothed on posterior margin. Operculum 0.03 mm. long, 0.04 mm. wide, sub-semicircular, half filling orifice. Lingula little constricted, subparallel sided, rounded apically.

ADULT: *Female*, antenna (Fig. 20*b*); segment 3, 0.18 mm.; 4, 0.045 mm.; 5, 0.05 mm.; 6,

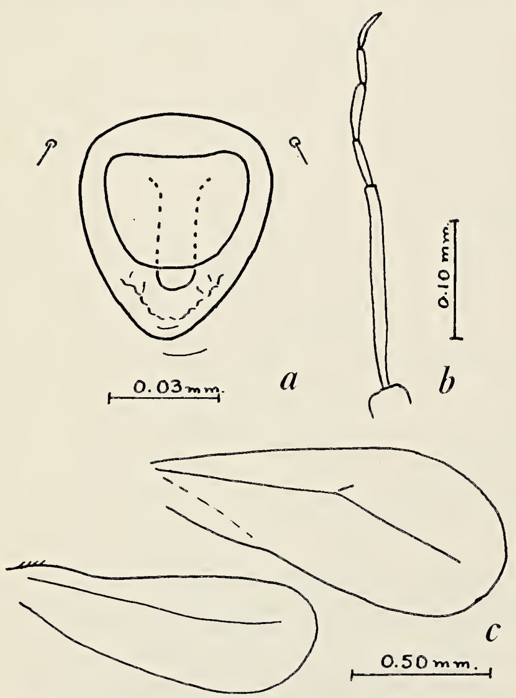

FIG. 20. *Aleyrodes fodiens* Mask. Pupal case: *a*, Vasiform orifice. Adult female: *b*, Antenna; *c*, wings.

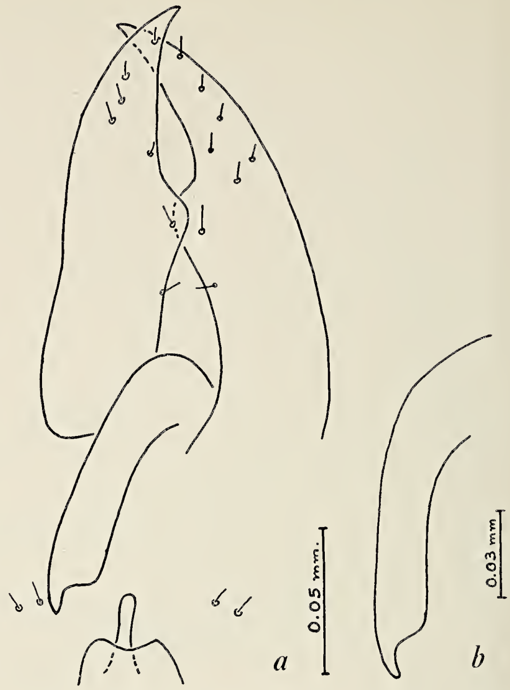

FIG. 21. *Aleyrodes fodiens* Mask. Adult male: *a*, Vasiform orifice, claspers, and penis; *b*, penis, lateral view.

0.04 mm.; 7, 0.035 mm. Wings (Fig. 20*c*) white, unspotted, forewing 1.3 mm. long, stub of R_1 present. *Male*, operculum (Fig. 21*a*) length 0.02 mm., width apically 0.02 mm. wider basally, emarginate apically. Lingula rounded apically. Clasper (Fig. 21*a*) 0.15 mm. long, apex acute, prominent almost angulate bulge bearing two setae at mid-length mesally, four or five setae apically. Penis (Fig. 21*b*) subparallel sided in lateral view, abruptly angled to base of tooth which is fairly long and acute.

LECTOTYPE: Pupal case on slide mount in Maskell collection.

TYPE LOCALITY: Reefton. Collect. R. Raithby.

FOOD PLANT: *Drimys* (*Wintera*) *axillaris.*

MATERIAL: Unmounted duplicate material in Maskell collection. Pupal cases and adults from *Wintera* at Waiho. Collect. L.J.D. 20/11/50.

Quaintance and Baker (1917) remark that *fodiens* is not a typical *Dialeurodes*. Although it is subcircular rather than oval and the lingula is not noticeably knobbed it would appear to fit the genus *Aleyrodes* best and I have returned it to that genus.

Aleyrodes winterae Takahashi

Figs. 22, 23

Aleyrodes winterae Takahashi 1937: 251–253.

LARVA: Unknown.

PUPAL CASE: (Fig. 22). Length 0.85–0.97 mm., width 0.72–0.81 mm. Colour light yellowish-brown. Shape subcircular, flat but slightly raised, sides not vertical. Margin (Fig. 23*a*) obscurely and irregularly crenulate. No thoracic or abdominal tracheal folds, pores or combs. Submargin indicated by a faint line anteriorly. Posterior marginal setae present. One pair of minute paramedian setae in cephalic region and one pair on each of the first and eighth abdominal segments. Ten submarginal setae on each side, six on the cephalothorax and four on the abdomen. Caudal setae not differentiated from submarginal setae. There are paired paramedian wrinkled areas on the anterior borders of abdominal segments 2–6 inclusive and also on the meso- and meta-thorax. Faint paired paramedian pores on abdominal segments 1–7. Vasiform orifice (Fig. 23*b*) 0.07 mm. long, 0.05 mm. wide, subtriangular, floor reticulate. Operculum 0.03 mm. long, 0.035 mm. wide, half filling orifice. Lingula finger-like, bluntly pointed, little constricted basally.

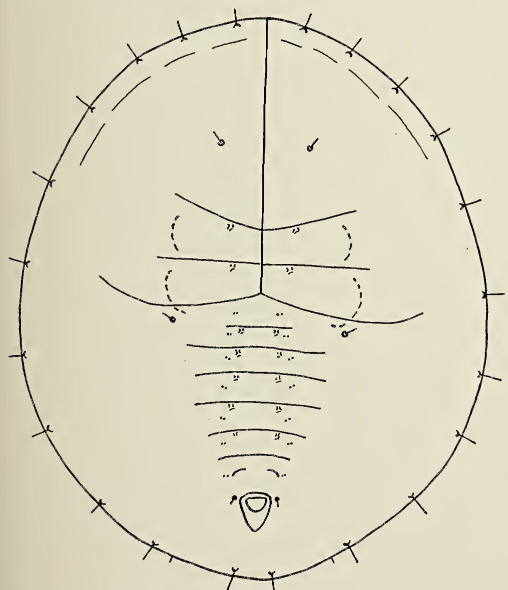

FIG. 22. *Aleyrodes winterae* Takahashi. Pupal case, dorsal.

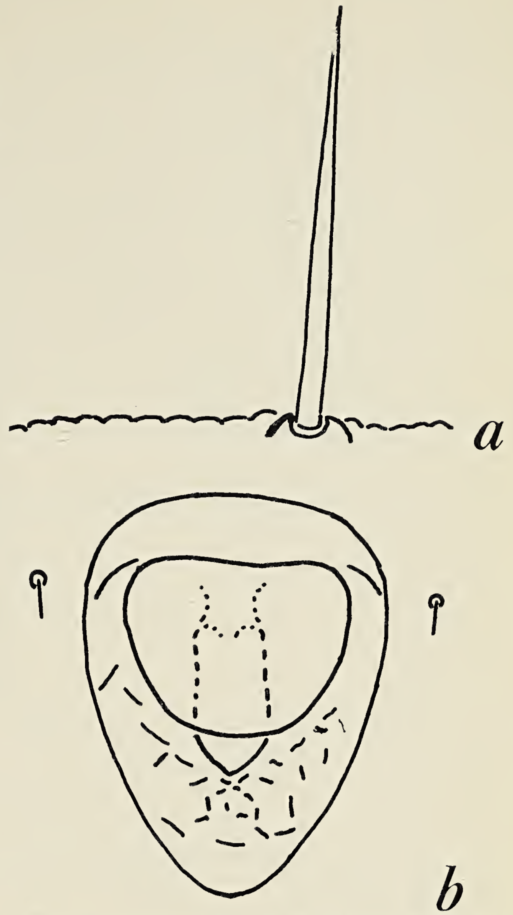

FIG. 23. *Aleyrodes winterae* Takahashi. Pupal case: *a*, Margin and seta; *b*, vasiform orifice.

ADULT: Unknown.

COTYPES: In the Department of Agriculture Research Institute, Formosa, and in the British Museum.

TYPE LOCALITY: Palmerston North. Collect. W. Cottier.

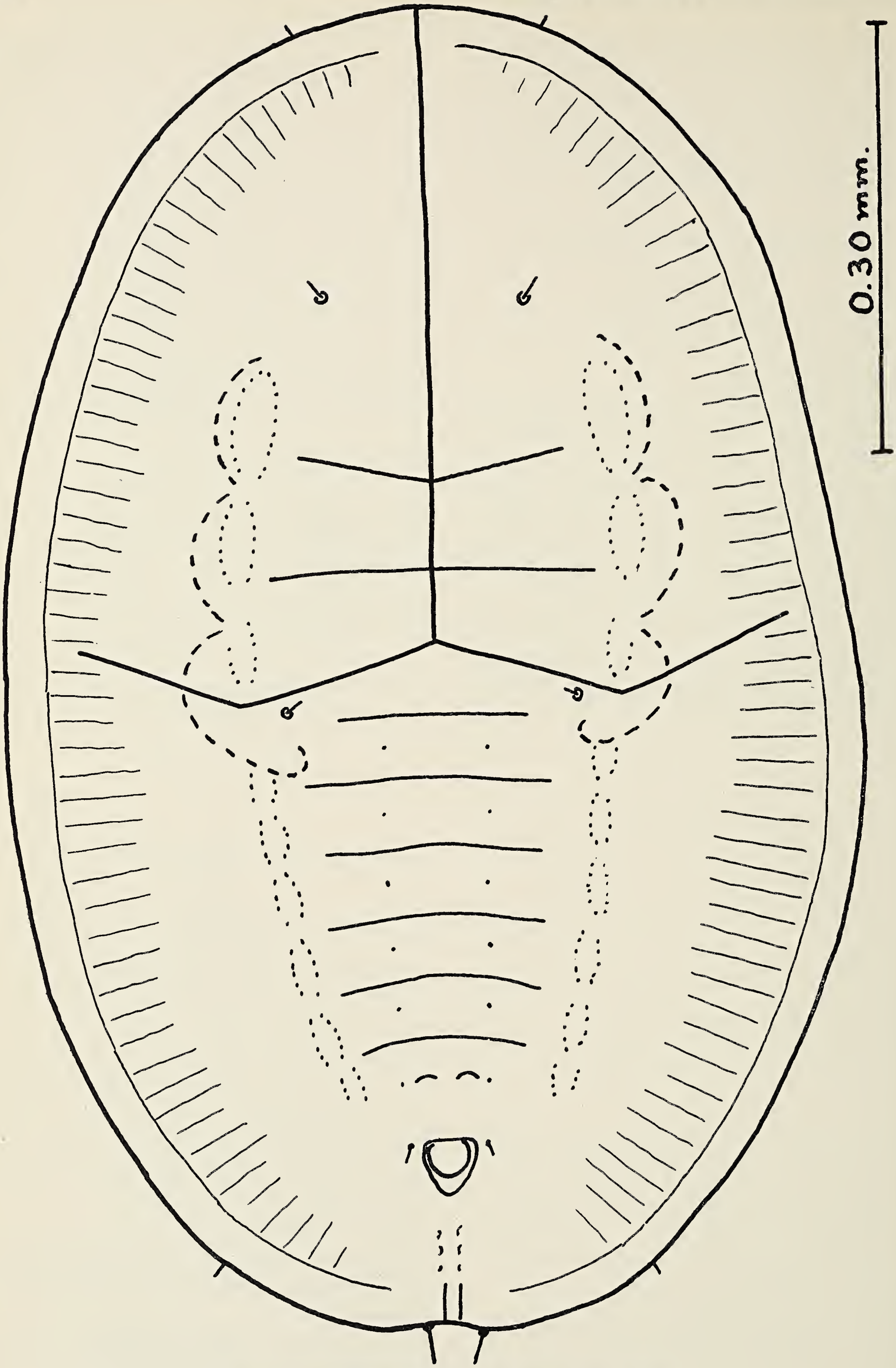

FIG. 24. *Aleuroclava eucalypti* n. sp. Pupal case. dorsal.

FOOD PLANT: *Wintera colorata.*

MATERIAL: Several specimens found in association with *fodiens* on *Wintera axillaris* in Maskell unmounted duplicate material collected by R. Raithby in Reefton.

This species is not a typical *Aleyrodes* according to Takahashi. It is evidently closely related to *fodiens*. The pupal cases are thicker and more raised than those of *fodiens*. Both species make shallow pits on the leaf.

Genus ALEUROCLAVA Singh

Aleuroclava eucalypti n. sp.
Figs. 24–26

LARVA: Unknown.

PUPAL CASE: (Fig. 24). Length 0.90 mm.–1.12 mm., width 0.56–0.71 mm. Colour white or colourless. Shape elliptical, flat. Margin (Fig. 25*a*) crenulated, 20–26 crenulations in 0.1 mm. Thoracic and abdominal tracheal folds, pores and combs absent. Submargin defined by submarginal line. Mesad of the submarginal line are faint radial depressed lines with between them radial rows of 7 or 8 tubercles of which the one nearest the margin is often larger. Segmentation as in figure. Thoracic area and abdominal segments 2–6 bounded laterally by a tubercular line. A pair of paramedian pores on each of abdominal segments 2–7. One pair of cephalic setae, one pair first abdominal, one pair 8th abdominal and one pair caudal 0.035 mm. long. Vasiform orifice (Fig. 25*b*) length 0.039 mm., width 0.036 mm. subcircular, raised above abdomen, toothed posteriorly and reticulate on floor. Operculum length 0.023 mm., width 0.028 mm., slightly subtrapezoidal, subtruncate apically. Lingula parallel sided, rounded apically, barely projecting beyond operculum, 0.02 mm. long. Anal furrow short, not extending halfway to orifice.

ADULT: *Female*, antennae: segment 2, 0.06 mm. long; 3, 0.14 mm.; 4, 0.04 mm.; 5, 0.045 mm.; 6, 0.035; 7, 0.045 base longer than flagellum. Wings white, immaculate, fore-

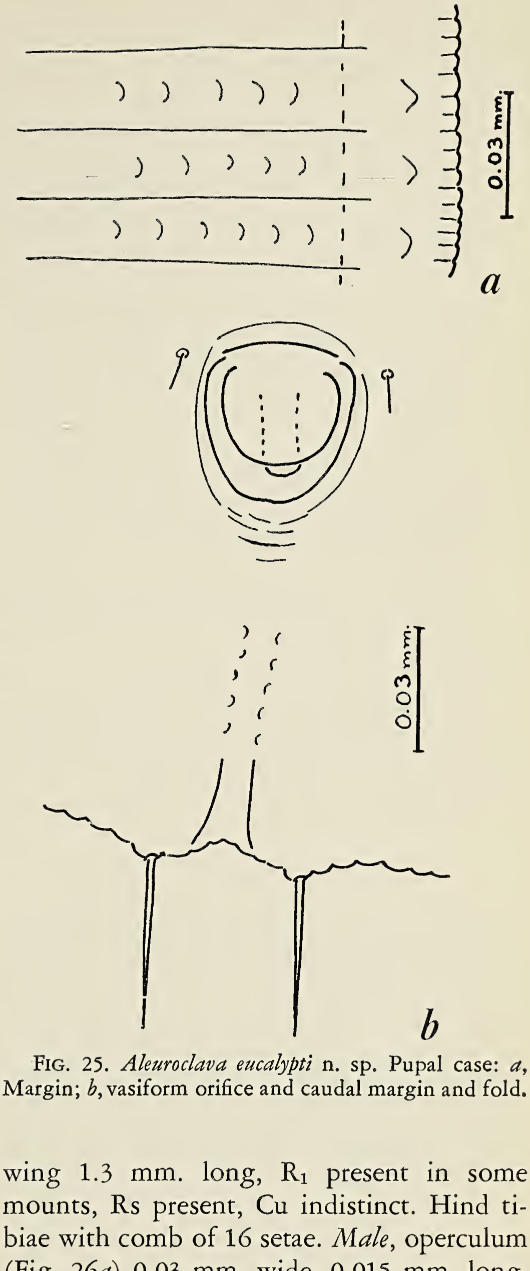

FIG. 25. *Aleuroclava eucalypti* n. sp. Pupal case: *a*, Margin; *b*, vasiform orifice and caudal margin and fold.

wing 1.3 mm. long, R_1 present in some mounts, Rs present, Cu indistinct. Hind tibiae with comb of 16 setae. *Male*, operculum (Fig. 26*a*) 0.03 mm. wide, 0.015 mm. long. Lingula strap-shaped 0.025 mm. long, 0.005 mm. wide, projecting beyond orifice, subtruncate apically with corners angularly excised. Penis (Fig. 26*b*) length 0.11 mm., in lateral view, parallel sided, sinuate, truncate apically.

HOLOTYPE: Pupal case on slide mount deposited with Maskell collection.

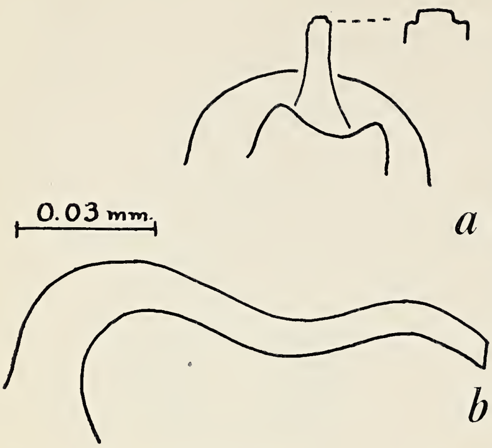

FIG. 26. *Aleuroclava eucalypti* n. sp. Adult male: *a*, Vasiform orifice; *b*, penis, lateral view.

TYPE LOCALITY: Waikakaho, Blenheim. Collect. L.J.D. 3/11/50.

FOOD PLANT: *Eucalyptus globulus.*

This species was almost certainly introduced into New Zealand with the food plant and therefore is of Australian origin.

REFERENCES

COCKERELL, T. D. A. 1902. The Classification of the Aleyrodidae. *Acad. Nat. Sci. Phila., Proc.* 54: 297–383.

KIRKALDY, G. W. 1907. A Catalogue of the Hemipterous Family Aleyrodidae. Bul. 2, Div. Ent. Hawaii, pp. 1–102.

MASKELL, W. M. 1879. On Some Coccidae in New Zealand. *New Zeal. Inst. Trans. and Proc.* 11: 187–228.

——— 1880. Further Notes on New Zealand Coccidae. *New Zeal. Inst. Trans. and Proc.* 12: 291–301.

——— 1890. On Some Aleurodidae from New Zealand and Fiji. *New Zeal. Inst. Trans. and Proc.* 22: 170–176.

——— 1896. Contributions towards a Monograph of the Aleurodidae, a Family of the Hemiptera Homoptera. *New Zeal. Inst. Trans. and Proc.* 28: 411–449.

QUAINTANCE, A. L. 1908. Aleyrodidae (Homoptera) Genera Insect. Fasc. 87.

QUAINTANCE, A. L., and A. C. BAKER. 1913. Classification of the Aleyrodidae. Part 1. *U. S. Bur. Ent., Tech. Ser. Bul.* 27: 1–93.

——— 1914. Classification of the Aleyrodidae. Part 2. *U. S. Bur. Ent., Tech. Ser. Bul.* 27: 95–109.

——— 1915. The Classification of the Aleyrodidae. *U. S. Bur. Ent., Tech. Ser. Bul.* 27. Contents and Index. P. xi.

——— 1917. A Contribution to our Knowledge of the White Flies of the Subfamily Aleyrodinae (Aleyrodidae). *U. S. Natl. Mus., Proc.* 51: 335–445.

RUSSELL, L. M. 1948. The North American Species of Whiteflies of the genus *Trialeurodes. U. S. Dept. Agr., Misc. Pub.* 635: 1–85.

SAMPSON, W. W. 1943. A generic Synopsis of the Hemipterous Superfamily Aleyrodoidea. *Ent. Amer.* (*N. S.*) 23: 173–223.

TAKAHASHI, R. 1937. A New Species of Aleyrodidae from New Zealand (Hemiptera). *Nat. Hist. Soc. Formosa, Trans.* 27 (170): 251–53.

A Taxonomic Study of the Genus *Eugenia* (Myrtaceae) in Hawaii[1]

Kenneth A. Wilson[2]

The pantropic genus *Eugenia* (Myrtaceae) is represented in the forests of Hawaii by several species. A recent taxonomic treatment of the genus by Merrill and Perry (1939) divided the greater number of species of *Eugenia* into the genera *Syzygium* and *Eugenia* sensu strictu. A later study by Henderson (1947), based on the Malayan species, rejected this classification.

According to the Merrill and Perry classification, both *Syzygium* and *Eugenia* sensu strictu are present in the Hawaiian flora. Therefore, it seemed that an evaluation of the recent generic treatments based on these representatives would be of value. My study of the generic status of *Eugenia* and *Syzygium* led to the question of the specific status of the indigenous Hawaiian members. As a result of my investigations I have rejected the transfer of species of *Eugenia* to *Syzygium*, described a new species from the island of Molokai, and reduced two species and one variety to synonomy.

ACKNOWLEDGMENTS

Prof. Harold St. John suggested to me that the problem of the generic status of *Eugenia* was in need of further study. I have undertaken this problem under his guidance and am indebted to him for his help and encouragement. I wish to thank Miss Marie C. Neal, Curator of the Herbarium of the Bernice P. Bishop Museum, for her helpful and valuable assistance and for the opportunity to work on the specimens in the herbarium. Dr. Rogers McVaugh, Curator of Phanerogams of the Herbarium of the University of Michigan, has generously made the space and facilities of the herbarium available to me for continuing this study. I gratefully acknowledge the assistance of Dr. Joseph F. Rock, who provided valuable information based on his knowledge and experience with the Hawaiian flora.

I am indebted to the following herbaria for the loan of herbarium specimens, photographs of types, and other valuable materials: Herbarium of Bernice P. Bishop Museum, Gray Herbarium, Herbarium of the Royal Botanical Gardens at Kew, Botanische Staatssammlung München, Herbarium of the University of Michigan, Herbarium of the New York Botanical Gardens, and United States National Herbarium.

HISTORY OF THE GENUS

Since Linnaeus' treatment of *Eugenia* in *Species Plantarum* (1753: 470), more than 800 species have been described or transferred to this genus. Many botanists have been dissatisfied with the wide range of difference in form shown by the members of the genus.

[1] Part of a thesis submitted to the Graduate School of the University of Hawaii in partial fulfillment of the requirements for the degree of Master of Science.

[2] Department of Botany, University of Michigan, Ann Arbor, Michigan. Manuscript received February 10, 1956.

One of the most comprehensive reclassifications of *Eugenia* was proposed by Niedenzu (1893). He established several segregate genera which were based mainly on the characters of the flower. His system was adopted by many workers, but, because of the lack of distinct generic limits, many other botanists continued to consider *Eugenia* in a broader sense. Later studies of the members of the group led more and more botanists to reject Niedenzu's classification and to return the segregated genera to *Eugenia*.

Because of the great number of species described in *Eugenia* the group has become rather unwieldy, and Merrill and Perry (1938*a*, 1938*b*, 1939) proposed a new systematic treatment of the group. They redefined some of the earlier proposed segregates of the genus. The new systematic treatment which they proposed is based on the structure of the seed. According to them, species of *Eugenia* are diagnosed as having a pericarp which is easily crushed and "the seed is free, the testa is smooth, chartaceous to cartilaginous and mostly lustrous, and the cotyledons are mechanically inseparable, i.e., they have grown together in such a way that often the line of their opposing faces is scarcely distinguishable." *Syzygium*, one of the segregate genera, is described as having "fruits that when dried are not too easily broken, and, when opened, the embryo (not the entire seed) falls out leaving the roughish seed coat more or less loosely adhering to the pericarp; the embryo has two distinct cotyledons usually attached near the middle of the opposing faces which conceal the hypocotyl within."

In a monograph of the species of *Eugenia* in Malaya, R. M. Henderson (1949) critically analyzed Merrill and Perry's classification. Henderson, in his study, decided that neither the degree of adherence of the seed coat to the cotyledon, nor the nature of the cotyledons themselves is consistent enough to be regarded as a good generic character. In fact, he gives detailed descriptions of the seeds of several different species which illustrate an intergrading series from those with two distinct and separate cotyledons to those with the cotyledons completely fused. On the basis of these observations he rejects the transfer of species from *Eugenia* to *Syzygium*.

In 1953 Ingle and Dadswell published the results of their studies of the wood anatomy of several Pacific Myrtaceae.[3] They concluded that the anatomy of the wood of *Eugenia* provides ample characters for splitting the genus. They added that the "suggested split on anatomical grounds involved only the two groups *Eugenia A* [corresponding to *Eugenia* sensu strictu] and *Eugenia B* [including the genera *Acmena*, *Cleistocalyx* and *Syzygium*]."[4]

The most recent treatments of the genus have been inconsistent. By far the majority of workers (Airy Shaw, 1949; Backer, 1945; Degener and Ludwig, 1952) have accepted Merrill and Perry's classification without any apparent critical study. A few botanists (White, 1945; Amshoff, 1942), seemingly in doubt as to the validity of this system, have hesitated to adopt it.

EVALUATION OF THE RECENT GENERIC TREATMENTS

The Hawaiian flora, although predominantly Asiatic in its affinities, includes representatives of the tropical regions of both the Old World and the New World. Because of the uniqueness of the Island flora in this respect, the Hawaiian Islands may be considered an ideal region for evaluating the recent treatment of *Eugenia*.

The two most important features used by Merrill and Perry in segregating the genera are: (1) the nature of the embryo, and (2) the degree of adherence of the testa to the cotyledons. On the basis of these characters

[3] See also Dadswell and Ingle, 1947.

[4] Since this paper went to press Kathleen M. Pike published the results of her studies in the pollen morphology of the Myrtaceae. (*Austral. Jour. Bot.* 4(1): 13–53, 1 pl., 1956.) She found that the pollen grains of "*Eugenia* A" are distinct from those of "*Eugenia* B" and thereby adds support to the groupings of Ingle and Dadswell based on the wood anatomy.

Merrill and Perry (1938*a*, 1938*b*, 1939), in studies of Indo-Chinese, Chinese, and Bornean species of *Eugenia*, redefined the group, placing most of the species of those regions in the genus *Syzygium*. Geographically, their new concept limits *Eugenia* mainly to tropical America, and *Syzygium* primarily to the tropics of the Old World.

The genus *Eugenia* in the Hawaiian Islands is represented by eight species as I interpret them. In my opinion, according to the Merrill and Perry system, four of the Hawaiian representatives of *Eugenia* would be classified in the segregate genus *Syzygium*, while four would fall in *Eugenia* sensu strictu.

Eugenia malaccensis and *E. Jambos* have fruits which contain a rather large seed loosely attached within the pericarp. In both species the embryo has two distinct, fleshy cotyledons. The surface of the cotyledons is very rugose and the thick seed coat adheres firmly to it. Young seedlings of *E. malaccensis* were found growing which had the two cotyledons still attached. The pericarp had rotted away and no evidence of it could be seen, but on the surfaces of the cotyledons remains of the seed coat were still present.

In fruits of *Eugenia Cumini* the fleshy pericarp peels off, leaving the seed coat firmly adhering to the cotyledons. The cotyledons are fleshy and distinct. In dried, raw fruits the seed coat readily peels off with the pericarp. However, when boiled, the pericarp may be easily removed without disturbing the seed coat.

Upon removal of the pericarp the testa of *Eugenia sandwicensis* also remains attached to the cotyledons. The two fleshy cotyledons are not consolidated. In boiled dried material, depending on the amount of care given it, the pericarp may or may not peel away from the seed coat.

The seeds of *Eugenia rariflora* and *E. koolauensis* have their cotyledons plainly separated, partly fused, or entirely consolidated. When the cotyledons are consolidated the line of their opposing faces is not evident. In both dried and fresh fruits the thin seed coat peels off with the pericarp.

On the basis of the studies I have made, it seems evident that neither the character of the seed coat nor that of the embryo offers a satisfactory basis for the reclassification of the group. Neither one of the characters is constant. The degree of fusion of the cotyledons varies even within a single species.

The conclusions I have drawn on the basis of investigations of the Hawaiian representatives of *Eugenia* strongly support Henderson's rejection of the segregation of species of *Eugenia* into the genera *Syzygium* and *Eugenia* sensu strictu.

No attempt was made to study the wood anatomy of the Hawaiian species of *Eugenia*. In view of Ingle and Dadswell's findings (1953) I suggest that additional more extensive investigations may reveal other morphological characters to support their conclusions. The characters of the seed, since they are so variable, do not justify the split.

VARIATION AND DISTRIBUTION OF THE SPECIES IN HAWAII

The genus is represented in Hawaii by only four indigenous species, three of which are endemic. Of these four, *Eugenia rariflora* and *E. sandwicensis* show the greatest degree of variation within the entire group. Both show variations in leaf size ranging from very small to rather large.

The greatest degree of variation is seen in *Eugenia sandwicensis*. The forms of *E. sandwicensis* with the larger leaves are found most often on Kauai; the forms with elliptical and elliptical-lanceolate leaves are more prevalent on Maui, and most of the Oahu representatives have the smaller obovate leaves. On Lanai the majority of the representatives of this species have small obovate leaves similar to those of the most common forms on Oahu. Most of the members on Molokai have leaves which resemble the forms on Maui, although in general they are not as long. It is possible

for a person who is familiar with the species to determine, in the majority of cases, from which one of the islands a specimen was collected. However, this broad generalization of geographical distribution is not constant, and almost all forms are present on each of the islands where the species occurs.

Of the naturalized species *Eugenia Cumini* is by far the most widely distributed. *E. malaccensis* is confined mostly to shaded, moist valleys where it is likely they were planted originally by the Hawaiians. Both *Eugenia Jambos* and *E. uniflora* are only sparsely distributed in the native forests.

These introduced species are remarkably constant in their characters and show no significant degree of variation.

EXPLANATIONS

Unless otherwise indicated, the specimens studied are in the Bernice P. Bishop Museum. The standard abbreviations of Lanjouw and Stafleu (1954) are used to indicate the locations of the other specimens:

BISH—Bernice P. Bishop Museum, Honolulu
GH—Gray Herbarium, Cambridge
K—Royal Botanical Gardens, Kew
M—Botanische Staatssammlung, München
MICH—University of Michigan, Ann Arbor
NY—New York Botanical Gardens, New York
US—United States National Herbarium, Washington

I have examined the following numbers of fruits and seeds of the species included in this problem. When possible both fresh and dried material was studied.

	Fresh	*Dried*
Eugenia malaccensis	15	3
E. Jambos	—	5
E. sandwicensis	100	60
E. Cumini	50	20
E. uniflora	10	5
E. rariflora	—	15
E. koolauensis	20	10

TAXONOMY

Eugenia L., Sp. Pl. 470, 1753.

Syzygium Gaertn., Fruct. 1: 166, t. 33, 1788.
Jambosa DC., Prodr. 3: 286, 1828.

Trees or shrubs. Shoots glabrous or pubescent. Leaves simple, opposite, glandular-punctate, pinnately veined with a continuous intramarginal vein. Leaf scar with a single vascular bundle. Flowers single or in pairs, axillary, or in terminal, or axillary cymes or racemes, or inflorescence on leafless branches. Calyx tube[5] globose to elongate-turbinate, extending beyond the ovary or not so, usually minutely glandular-punctate; calyx lobes 4, large persistent and spreading, or small and early deciduous; petals 4, free and spreading persistent or caducous, or cohering and falling off as a calyptra; stamens numerous, free on a staminal disk lining the calyx tube or inserted on the margin of the calyx tube; anthers versatile, cells splitting longitudinally, connective gland present; style filiform, stigma small; ovary inferior, 2-celled. Fruit a berry with only 1 seed (rarely 2) developing from the many ovules, crowned by the persistent calyx lobes or by the truncate scars of the calyx lobes; umbilicus sometimes present; seeds large with a thin membranaceous or a thick cartilaginous or fibrous seed coat; cotyledons thick, fleshy, completely free or partly or entirely fused.

Type species: *Eugenia uniflora* L.

KEY TO THE SPECIES IN HAWAII

A. Flowers in cymes or racemes; calyx tube extending beyond the ovary.
  B. Calyx tube 10–30 mm. long.
    C. Inflorescence axillary from older leafless nodes or rarely from leafy

[5] "Calyx tube" is used here, as is customary in treatments of the genus, to refer to the inferior ovary and especially to the tissues adhering to it. There is no intention to imply the exact morphological nature of the inferior ovary of *Eugenia* by the use of this term. The origin of the inferior ovary in this genus has not as yet been satisfactorily determined.

nodes; petals not reflexing at anthesis; stamens 1–2 cm. long; leaves 5–9 cm. wide, elliptical to obovate-oblong. . . . . **1. E. malaccensis**

C. Inflorescence terminal; petals reflexing at anthesis; stamens 2–5 cm. long; leaves 2.5–5 cm. wide, linear-lanceolate. . . . **2. E. Jambos**

B. Calyx tube 3–8 mm. long.

D. Stamens 20–30, included in the calyx tube, inflexed, 0.5–1.5 mm. long; fruit pink to deep red. . . . . **3. E. sandwicensis**

D. Stamens more than 50, exserted, spreading, 3–7 mm. long; fruit dark purple or black. **4. E. Cumini**

A. Flowers single or in pairs, axillary; calyx tube not extending beyond the ovary.

E. Fruits longitudinally 8-ribbed; calyx lobes membranaceous . . **5. E. uniflora**

E. Fruits not ribbed; calyx lobes fleshy.

F. Leaves flat or slightly concave, glabrous beneath or only sparingly puberulent near midrib. . . . . **6. E. rariflora**

F. Leaves strongly concave and with the entire lower surface puberulent.

G. Fruit orange-yellow; flowers with punctiform pistil . . . . **7. E. koolauensis**

G. Fruit red; flowers with peltate pistil. . . . . . **8. E. molokaiana**

1. **Eugenia malaccensis** L., Sp. Pl. 470, 1753.

Jambosa malaccensis (L.) DC., Prodr. 3: 286, 1828.

Syzygium malaccense (L.) Merr. and Perr., Arnold Arboretum, Jour. 19: 215, 1938.

Tree 8–20 m. tall; branches greyish-brown, smooth, glabrous; leaf scars 3–6 mm. wide, lunate-elliptic, pale; bundle scar large, transverse; leafy branches brown, glabrous, 3–5 mm. in diameter, angled or terete; internodes 1.5–6 cm. long; leaves 14–25 cm. long, 5–9 cm. wide, elliptical to obovate-oblong, apex abruptly acute or obtuse, base cuneate to abruptly cuneate; margin entire or slightly undulate; blade coriaceous, above glabrous, shiny, dark green, sparsely black punctate, below pale, glabrous, minutely black punctate; midrib light green, shallowly impressed above, elevated below; primary lateral veins alternate or opposite, 8–14 on a side 1–2.5 cm. apart, irregularly ascending at 140–150°, meeting in a conspicuously sinuate, continuous intramarginal vein 0.5–1.5 cm. from leaf margin, smaller, continuous intramarginal vein 1–2 mm. from leaf margin, irregularly lobed, raised or impressed above, elevated below; the veinlets less distinct, raised-reticulate; petioles 1–1.5 cm. long, 3–4 mm. wide, reddish-green, glabrous; cymes axillary or on stems below leaves 2–5 cm. long; peduncle 5–10 mm. long, angled or terete, glabrous, reddish-green, pedicels when present, 2–8 mm. long, glabrous, reddish-green, articulate, but some flowers sessile; calyx tube green to reddish-green, 1–3 cm. long, 1–1.5 cm. wide, obconic, elevated above ovary, narrowing into a short pseudostalk 0.5–1.0 cm. long, subtended by 2 deltoid bracts 1–1.5 mm. long; calyx lobes 4, persistent, broad, rounded, 2–3 cm. long, 6–8 cm. wide, green; petals 4, spreading, obovate-orbicular, pink to red, glabrous, deciduous, glandular-punctate, 6–9 mm. long, 7–10 mm. wide, apex rounded or acuminate, base truncate; stamens numerous (about 100), exserted, 1.0–2.0 cm. long; filament slender, red, glabrous, terete above, flattened below; anthers white 9–12 mm. long, oblong; style red, subulate, 1.5–2 cm. long, glabrous; ovary 2-celled multiovulate; fruit obovoid 5–7.5 cm. long, 4–6 cm. in diameter, pinkish to dark red, umbilicate on top, crowned with truncate scars of the calyx lobes or calyx lobes persisting;

pericarp crisp, watery, 1.0–2.0 cm. thick; seed loosely attached within, subglobose, 1.5–2.0 cm. in diameter; seed coat fibrous, brown, 1 mm. thick, adhering closely to the rugose surface of the cotyledons; cotyledons 2, white or greenish, equal or unequal, not fused.

Common name: "Ohia ai," Mountain Apple.

DISTRIBUTION: Common in the moist gulches on the larger islands. Native to the Indo-Malayan region, it may now be found in cultivation, widely distributed in the tropics of the world.

Specimens examined:

HAWAIIAN ISLANDS: *Hillebrand and Lydgate; Mann and Brigham 119; U. S. Explor. Exped.* (NY).

KAUAI: Waioli Valley, along stream, alt. 100 m., Feb. 27, 1927, *MacDaniels 909*.

OAHU: Punaluu, stream bank, elev. 800 ft., Sept. 28, 1930, *St. John 10,581* (NY); Punaluu Valley, in dark forest in wet ground at bottom of Pig God trail, Sept. 2, 1932, *Degener 7,349;* Waikane-Schofield trail, side of trail, 1000 ft. alt., Dec. 2, 1951, *Wilson 46;* Koolauloa, Kaluanui, Sacred Falls Valley 700 ft. alt., May 18, 1952, *Wilson and Doty 137, 138, 139, and 141;* Kipapa Gulch, frequent at bottom of gulch, in "koa zone," *Egler 37–421;* Kalihi Valley, Jan. 1, 1920, *Garber 97;* Moanalua Valley, March 7, 1910, *Forbes 1465.0;* Kaumokunui Gulch, rich dark wet gulch at 1500 ft., April 13, 1936, *Degener 11,887* (NY, MICH); Waianae Mts.: Makaleha Valley, Jan. 14, 1929, *Neal;* Puu Kaupakuhale, 2nd gulch of N.E. slope of Puu Kaala, in wood, May 14, 1933, *St. John 13,173*.

MOLOKAI: Mapulehu, April 1910, *Rock*.

MAUI: Kailua, Haleakala, April 1911, *Rock*.

HAWAII: Hilo, May 1909, *Faurie*.

Eugenia malaccensis was most likely introduced into the Hawaiian Islands by the Polynesians. It may be found growing in large groves in moist, shaded valleys where it was probably originally planted and has subsequently become established.

2. **Eugenia Jambos** L., Sp. Pl. 470, 1753.

Jambosa Jambos (L.) Millsp., Field Mus. Nat. Hist., Bot. Ser. 2(1): 80, 1900.

Syzygium Jambos (L.) Alston, in Trimen, Fl. Ceyl. 6 (Suppl.): 115, 1931.

Tree 6–10 m. tall; branches brown to yellowish-brown, glabrate, longitudinally ridged; leaf scars rounded shield-shaped, 2.5–4 mm. wide, pale; stems of leafy branches 3–4 mm. in diameter, 4-angled or compressed, becoming terete in age, glabrous; internodes 1.5–3 cm. long; leaves 10–20 cm. long, 2.5–5 cm. wide, lanceolate or oblong-lanceolate, tapering to an acuminate apex, base cuneate; margin entire; blade coriaceous, above olive-green to reddish-green, glabrous, shiny, minutely pustulate, below paler, glabrous, minutely glandular-punctate; midrib shallowly impressed above, elevated below, light yellowish-green to reddish-green; primary lateral veins alternate or opposite, 10–15 on a side, 5–15 mm. apart, slightly elevated above, very prominent below, straight or slightly curved ascending at 140–150°, meeting in an irregularly lobed continuous intramarginal vein 3–5 mm. from leaf margin; the veinlets obscure above, distinctly raised-reticulate below; petiole 5–10 mm. long, 2–3 mm. wide, glabrous, dark reddish-green; racemes terminal, 6–10 mm. long, rachis 6–15 mm. long, 3–4 mm. wide, 4-angled brownish-green to reddish-green, glabrous; pedicels 7–15 mm. long, flower single on the pedicels, 3–6 cm. long, 6–8 cm. in diameter; calyx tube obconic, 1–1.5 cm. long, 7–10 mm. wide, elevated above ovary, narrowed into a short pseudostalk, glabrous or sparsely puberulous, minutely glandular-punctate, green or yellow-green, subtended by 2 caducous, glabrate, subulate bracts 0.8–1.0 mm. long; calyx lobes 4, persistent, fleshy, unequal, 1 pair 6–8 mm. long and 8–9 mm. wide, the smaller pair 4–6 mm. long, 8–9 mm. wide, below minutely glandular-punctate, glabrous or sparsely puberulous; petals 4, white to greenish-white, orbicular to ovate-orbicular, concave, spread-

ing, glandular-punctate, 1–1.7 mm. in diameter, glabrous; stamens numerous (about 200), creamy-white, 1–5 cm. long; filament slender, terete, creamy-white, glabrous; anthers white, oblong, 1–2 mm. long; style terete, subulate, 3–4 cm. long, glabrous, creamy-white to greenish-white, exserted or included; fruit subglobose, 2–4 cm. tall, 4–6 cm. wide, yellow or pinkish-yellow, minutely glandular-punctate, umbilicate on top, crowned by persistent calyx lobes, style often persistent; pericarp fleshy, 1–1.5 cm. thick; seed loosely attached within, subglobose, 2–2.5 cm. in diameter; seed coat 1 mm. thick, brown, coriaceous, closely adhering to the surface of the cotyledons; cotyledons white or greenish-white, equal or unequal, not fused.

Common name: "Ohia loke," Rose Apple.

DISTRIBUTION: Sparingly naturalized on probably all of the larger islands of Hawaii. Widely distributed in the tropics of the world.

Specimens examined:

KAUAI: Kokee Camp, becoming naturalized, July 5, 1926, *Degener 7,341* (NY); Waioli Valley, along stream, alt. 50 m., Feb. 27, 1927, *MacDaniels 908*.

OAHU: Waikane-Schofield trail, Waikane, 750 ft. alt., side of road, Dec. 2, 1951, *Wilson 45;* Waiahole, Jan. 23, 1909, *Rock 1,285 and 1,287;* Manoa, near Woodlawn, spreading locally, Apr. 1937, *Egler 37–423*.

MAUI: Iao Valley, Wailuku, roadside, elev. 800 ft., Feb. 9, 1930, *St. John 10,277* (BISH, NY).

HAWAII: Naturalized, *Degener 7,344;* South Kona, Honomalina, Ranch House, neat Kona highway, 1800 ft. alt., Sept. 7, 1952, *Chock 768;* near Glenwood, naturalized in pasture, June 23, 1929, *Degener 7,343* (NY).

Degener (1932–34) records that *Eugenia Jambos* was probably first introduced into Hilo from Rio de Janeiro by Mr. Bridge in 1853. It may now be found growing along road and trail sides and in other moist areas. Although Degener also records it as "definitely known from Kauai, Molokai, Oahu, Maui and Hawaii," no specimens of it were seen from Molokai.

3. **Eugenia sandwicensis** Gray, U. S. Explor. Exped. Bot. (official ed.) 519, 1854.

Syzygium sandwicense (Gray) Ndz., in Engl. and Prantl Pflzfam. 3(7): 85, 1893.

Eugenia sandwicensis var. *parvifolia* Hdb., Fl. Hawaii. Is. 129, 1888.

Syzygium oahuense Deg. and Ludw., Bot. Staatsaml. München, Mitt. 4: 113, 1952.

Tree or shrub, 3–25 m. tall; branches greyish-brown to reddish-brown, glabrous; leaf scars 1–4 mm. wide, rounded, shield-shaped, reddish-brown to yellowish-brown; young leafy branches green to reddish-green, glabrous, 1–4 mm. in diameter, distinctly 4-angled, angles winged; wings 0.2–2.0 mm. wide, branchlets becoming terete with age, dark red to reddish-brown bark scaling off in longitudinal strips exposing yellow-grey to reddish-yellow bark beneath; internodes 1–5 cm. long; leaves 2–14 cm. long, 1.5–5.0 cm. wide, obovate, ovate, elliptic or ovate-lanceolate, apex acute, obtuse, retuse, or apiculate, base truncate to cuneate, blade coriaceous, flattened or concave, margin entire, slightly revolute (rarely strongly so), above dark green or yellowish-green, shiny, glabrous, minutely glandular-punctate, below paler, dull, glabrous, minutely glandular-punctate, midrib pink to dark red, shallowly impressed above, elevated below; primary lateral veins alternate or opposite, 15–30 on a side, 2–8 mm. apart, irregularly ascending at 100–115°, meeting in an irregularly lobed intramarginal vein 0.5–1.5 mm. from leaf margin, raised on both surfaces but more distinct below; the veinlets raised-reticulate; petioles 2–10 mm. long, 1–2 mm. wide, reddish-brown, glabrous, cymes simple or compound, in axils of upper leaves, 5–8 cm. long; peduncle 2.5–3.5 cm. long, 1.5–3 mm. wide, 4-angled, winged, yellow-green to reddish-green, pedicels 2–4 mm. long, articulate; calyx tube turbinate, 3–4

mm. long, 3.5–5 mm. wide, glabrous, reddish-green to yellow-green, minutely glandular-punctate, subtended by two deciduous, glabrous, deltoid bracts 1–2 mm. long; the 4 calyx lobes 0.5 mm. long, imbricate, obtuse, reddish-green to dark red, early deciduous; petals 4, white to greenish-white, spreading, soon deciduous, usually discrete but sometimes united and falling off as a calyptra, ovate or obovate, often emarginate, glabrous, glandular-punctate, apex subacute or obtuse, base truncate, 2–3 mm. long, 2–3 mm. wide; stamens (about 30) inserted on the margin of the calyx tube, 0.5–1.5 mm. long, introrse, included; filaments white to pinkish, subulate, glabrous; anthers white 0.4–0.8 mm. long, orbicular-ovate; pistil white to reddish, glabrous, slender, 0.8–1.5 mm. long, included; ovules 4–10 in a cell; fruit light pink to dark red, 4–10 mm. high, 5–10 mm. wide, glabrous, shiny, minutely glandular-punctate, globose or elliptic, flattened on top, crowned by truncate scars of the calyx lobes; pericarp fleshy, 1–1.5 mm. thick; seed globose, elliptic or oblong-elliptic; seed coat reddish-brown, 0.5 mm. thick, loosely adhering to the pericarp, closely adhering to the smooth surface of the cotyledons; cotyledons equal, greenish or white, conspicuously glandular-punctate, not fused.

Type: U. S. Explor. Exped. "Oahu, Sandwich Islands; on the mountains behind Honolulu" (US).

Common name: "Ohia ha," known on Maui as "Paihi."

DISTRIBUTION: Endemic to the Hawaiian Islands. Found in the moist forests on Kauai, Oahu, Molokai, Lanai, and Maui; not known from the island of Hawaii.

Specimens examined:

KAUAI: Waimea, Alakai Swamp trail, 3800 ft. alt., rain forest, Dec. 25, 1952, *Wilson 206;* on Kaholuamanu above Waimea, Sept. 2–9, 1895, *Heller 2,241;* Kaholuamanu to Waimea, Oct. 27, 1916, *Hitchcock 15,558* (US); near Kaholuamanu, Kauluwehi Swamp, Oct. 25, 1916, *Hitchcock 15,520* (US); Wahiawa Mts., *Lydgate;* Wahiawa Mts., August 1909, *Forbes 181.K;* Wahiawa, Kahili Swamp, 2100 ft. alt., Lihue-Koloa Forest Reserve, Dec. 29, 1930, *St. John et al. 10,850;* Koloa, Laaukahi ridge, ¾ mile north of N.W. facing slope, 850 ft. alt., moist wooded gulch, Dec. 24, 1947, *St. John, Webster and Wilbur 23,007;* Laaukahi, Haiku, 1300 ft. alt., dense woods on precipitous slope, Dec. 22, 1933, *St. John and Fosberg 13,486;* Ka Loko Reservoir (Kilauea), Oct. 8, 1916, *Forbes 544.K;* E. fork of Kilauea River, rain forest, alt. 400 m., Feb. 11, 1927, *MacDaniels 654;* Wainiha, Wainiha Valley, moist lower forest, 800 ft. alt., Jan. 1, 1934, *St. John and Fosberg 13,929;* Wainiha, Wainiha Valley, 1000 ft. alt., on bank, side of road, in native forest, Dec. 31, 1952, *Wilson 235;* Hanakapiai, Napali Coast, forest on cliff, Jan. 2, 1931, *St. John et al. 10,992;* Hanakoa, Waiahuakua Stream, 350 ft. alt., Dec. 31, 1952, *Wilson and St. John 238;* Hii Mts., Oct. 22, 1916, *Forbes 652.K.*

OAHU: No locality: *Mann and Brigham 204; Hillebrand* (received July 1865) *311* (GH) (locality illegible, probably Oahu); *U. S. Explor. Exped.* (US). Koolau Mts.: Kahuku Army trail, July 1930, *Russ;* Hauula, Kaipapau Forest Reserve, Maakua-Papali ridge, wooded ridge, 1200 ft. alt., *St. John 13,372;* Kahana Valley, head of, Hauula Forest Reserve, 1000 ft. alt., lower woods, Dec. 10, 1933, *St. John 13,410;* Kahana Valley (south side of), ridge *mauka* of church, dense forest at 1500 ft., Nov. 5, 1950, *Degener and Silva 21,069* (US); Kahana Valley, head of, 1500 ft. alt., Aug. 31, 1924, *Harris;* Kaipapau on S. slope of ridge, 2500 ft. alt., Oct. 15, 1933, *Suehiro;* Punaluu, Dec. 3–4, 1908, *Rock 632 and 687* (GH), and *526;* Punaluu, Dec. 24–29, 1908, *Rock 377* (GH); Punaluu, Dec. 3, 1908, *Rock 149* (GH); Punaluu, wet mountain side, Nov. 30, 1929, *Tanaka;* Punaluu to Kaipapau, May 8–13, 1909, *Forbes;* Punaluu to Kaipapau, May 3–8, 1909, *Forbes and Cooke*, and *Forbes and Thompson;* Punaluu to Kaipapau, Nov. 14–21, 1908, *Forbes;* Kahana, Kaluanui, open woods, 2000 ft. alt., Nov. 30, 1929, *St. John*

10,099 (US); Waikane-Schofield trail, Waikane, 750–1250 ft. alt., Oct. 16, 1932, *Krauss;* Waikane-Schofield trail, near summit, 2000–3000 ft. alt., Sept. 16, 1932, *Yuncker 3,186* (US); Waikane-Schofield trail, 2200 ft. alt., Dec. 2, 1951, *Wilson 44;* north ridge of Kaaawa Valley, April 12, 1931, *St. John 11,085;* Heeia, Haiku Valley, Waiahole Forest Reserve, 500 ft. alt., in *Dicranopteris* thicket on ridge, Dec. 11, 1932, *St. John 12,260;* Konahuanui, Jan. 16, 1909, *Forbes 1,040;* Konahuanui—*Forbes 1,003*, and *1,309*, *Bryan 208*, *MacDaniels 124*, and *Heller 2,241* (US, MICH); Pupukea Military trail, Jan. 29, 1927, *MacDaniels 549;* Waimea-Malaekahana, 1900 ft. alt., March 22, 1953, *Ozaki 391*, *392*, *390*, *and 389;* Paalaa, South Opaeula Gulch, Nov. 9, 1930, *St. John 10,630;* Waipio, Kipapa Gulch, wet high mountain ridge, Nov. 10, 1929, *Tanaka;* Waipio, Kipapa Gulch, E. of Puu Kamana, wooded ridge, 1700 ft. alt., May 15, 1932, *St. John 11,683;* Waipio, Kipapa Gulch, south ridge, wooded slope, 1300 ft. alt., Nov. 10, 1929, *St. John 10,037;* Waipio, Kipapa Gulch, south ridge, 1400 ft. alt., woods, Oct. 29, 1929, *St. John 9,965;* Kawailoa, Kawaiiki Ditch trail, alt. 1340–1000 ft., Nov. 2, 1947, *Wilbur 257* (US); Kawailoa, Kawaiiki Ditch trail, moist *Metrosideros* forest, 1050 ft. alt., Jan. 17, 1953, *St. John 24,973;* Kawailoa, Kawaiiki Ditch trail, Aug. 15, 1922, *Skottsberg 230;* Kawailoa trail, rain forest, Oct. 31, 1937, *Hartt;* Kalauao ridge, Ewa Forest Reserve, moist woods, March 29, 1933, *St. John 13,028;* Halawa ridge trail, in moist forest, April 25, 1948, *Cowan 973; mauka* of Red Hill, in forest, Oct. 9, 1932, *Degener 7,328* (US, MICH); Kalihi-Nuuanu ridge, alt. 550 m., Jan. 23, 1927, *MacDaniels 156;* Kalihi-Nuuanu, Puu Lanihuli, main ridge running S.W. from Kalihi-Nuuanu, wooded ridge, 1600 ft. alt., Nov. 29, 1931, *St. John 11,176;* Kalihi-Nuuanu, Lanihuli trail, Sept. 17, 1908, *Forbes;* Lanihuli trail, Nov. 14, 1908, *Forbes;* Lanihuli trail, Dec. 10, 1908, *Forbes;* Nuuanu-Kalihi ridge, Aug. 13, 1922, *Skottsberg 156;* slope *mauka* from Tantalus, alt. 600 m., Nov. 1, 1926, *MacDaniels 98;* Pauoa, Konahuanui trail, Feb. 15, 1921, *Garber 229;* Pauoa flats, 1926, *Skottsberg 1,783;* Manoa, slopes back of Woodlawn, on crest of ridge, alt. 1000 ft., Dec. 31, 1942, *Kuykendall 49;* Olympus trail, alt. 700 m., Dec. 21, 1926, *MacDaniels 125;* Palolo-Manoa ridge, alt. 350 m., Dec. 21, 1926, *MacDaniels 122*; Palolo Valley, near first falls of Palolo, Nov. 16, 1919, *Garber 70;* Palolo Valley, Oct. 22, 1914, *Forbes 1929.0;* ridge between Palolo and Waialae-iki, Jan. 30, 1917, *Forbes 2411.0;* Palolo-Waialae ridge, Jan. 27, 1927, *MacDaniels 484 and 487;* Wiliwilinui ridge, 1600 ft. alt., March 16, 1952, *Wilson 106*, *108*, *111*, *113*, *115*, *116*, *117*, *118*, *119*, *and 120;* Niu Valley, summit ridge, Aug. 22, 1909, *Rock 4,840*. Waianae Mts.: Dupont trail, northern slope of Kaala, Feb. 29, 1949, *Degener et al. 19,428;* Dupont trail, north slope of Mt. Kaala, 2800 ft. alt., rain forest, Sept. 10, 1950, *Hatheway et al. 344;* eastern part of Kaala summit, Sept. 25, 1938, *Degener et al. 12,247* (NY); Kaala, Oct. 13, 1929, *Yoshinaga;* Mokuleia, 1200 ft. alt., July 18, 1924, *Wilder 1,287;* Makaha Valley, Feb. 12–19, 1909, *Forbes;* Honouliuli, ridge above Kupehau, dry brushy slope, alt. 650 m., June 30, 1935, *Fosberg 10,986;* Palehua, Aug. 23, 1922, *Skottsberg 207;* slope south of Palawai Gulch, *ca.* 2700 ft., March 27, 1948, *Wilbur 602*.

MOLOKAI: Olokui, 3000 ft. alt., ridge between upper forks of Wailele stream, rain forest, Feb. 6, 1948, *St. John and Wilbur 23,343;* Halawa, ridge south of valley, Aug. 1912, *Forbes 477.Mo.* (US); Kaluaaha, April 1910, *Rock 7,060* (GH); Kaluaaha, rain forest, June 28, 1928, *Degener 7,323* (GH); Pukoo, June 1910, *Faurie 434*.

LANAI: Aug. 1913, *Munro 15;* Sept. 1917, *Forbes 361.L* (US); Waiakeahua Gulch, in decadent, deer devastated forest at 2500 ft., Aug. 4, 1949, *Degener and Murashige 20,322* (US); Waiakiola Valley, July 28, 1910, *Rock 8,056* (GH): Kaiholena, *Munro 6;* Lanaihale, July 28, 1940, *Degener 12,976* (US); Puu Aalii, Kealia Aupu-Kaunolu divide, lower forest,

April 14, 1938, *St. John 18,851;* mountains near Koele, June 1913, *Forbes 78.L;* mountains near E. end, June 1913, *Forbes 275.L.*

MAUI: Makawao, Oct. 1910, *Rock 8,617* (US); April 1911, *Curran 62* (US); upper ditch trail Haleakala, Oct. 13, 1922, *Skottsberg 808;* Kailua, north slope of Haleakala, June 13, 1920, *Forbes 2499.M* (US); Kailua, Dec. 25, 1908, *Rock;* Kipahulu, 2500 ft. alt., Kaukaua Gulch, west ridge, summit of, *Acacia Koa* woods, Dec. 28, 1936, *St. John and Catto 17,806;* Nahiku, July 1910, *Forbes;* along ditch near Oopuola stream, lower rain forest, July 7, 1927, *Degener 7,324* (US); Puu Kukui, upper forest, 3–5000 ft., Sept. 25, 1916, *Hitchcock 14,804* (US); near where trail leaves tunneled stream for Mt. Eke climb, rain forest, Aug. 27, 1927, *Degener and Wiebke 2,307* (US, MICH).

This species exhibits extreme variation, especially in the leaves. The leaves are of various shapes, with a great number of intermediate forms, and they range in size from 14 × 5 cm. to 2 × 1.5 cm. The obovate leaf with an obtuse apex is most frequently encountered, but even on a single branch with leaves predominantly of this shape, others with ovate leaves and acute apices may be found. Of all the characters the flowers are the most constant.

No combination of characters was found on which a separation of the various forms could be based. Any attempt at reclassifying the group always disclosed intergrading forms which rendered the system impractical.

The absence of this widely distributed species on the island of Hawaii is peculiar. Rock (1913*a*) lists this species as occurring "on all islands of the group," but no single collection of it was found from Hawaii.

4. **Eugenia Cumini** (L.) Druce, Bot. Exch. Club Brit. Is., Rpt. 3: 418, 1914.

Myrtus Cumini L., Sp. Pl. 471, 1753.
Eugenia Jambolana Lam., Encycl. 3: 198, 1789.
Syzygium Cumini (L.) Skeels, U. S. Dept. Agr., Bul. 248: 25, 1912.

Tree 6 to 20 m. tall; branches pale yellowish-grey, glabrous, in age the bark greyish-white; leaf scars 2–4 mm. wide, rounded shield-shaped, yellowish-grey; leafy branchlets 1–3 mm. in diameter, terete or slightly angled, glabrous, pale brown to greyish-white; internodes 1.5–4.5 cm. long; leaves opposite, 7–18 cm. long, 3–8 cm. broad, oblong-ovate to elliptic-oblong, apex shortly or abruptly acuminate, rarely obtuse, base broadly cuneate narrowing toward petiole, margin entire or slightly undulate, blade coriaceous, above olive-green, minutely glandular-punctate, glabrous and shiny, below dark yellowish-green, dull, minutely pitted or pustulate, glabrous; midrib shallowly impressed above, elevated below; primary lateral veins numerous, alternate or opposite, 25–40 on a side, 2–5 mm. apart, irregularly ascending at 140–150°, meeting in an irregularly lobed intramarginal vein 1–3 mm. from leaf margin, raised on both surfaces; the veinlets raised-reticulate; petioles 1–2.5 mm. long, 1 mm. wide, glabrous; inflorescence cymose, on previous years' branches or occasionally in axils of the leaves, rarely terminal, 4–12 cm. long; peduncle 1–3 cm. long, terete or slightly angled, glabrous, subtended by two deciduous, subulate bracts 0.5–1.5 mm. long, glabrous; pedicels decussate, articulate, slender terete or slightly angled, subtended by one deciduous subulate bract; flower sessile, calyx tube campanulate, 3–5 mm. long, 2–3 mm. across, brownish-pink, glabrous, finely glandular-punctate, narrowing into a stout psuedostipe, subtended by 2 deciduous bracts; bracts reddish-brown, deltoid, 1–1.5 mm. long; calyx lobes 4, quickly deciduous; petals 4, white, minutely glandular-punctate, orbicular, concave, 2–3 mm. in diameter, falling off as a calyptra; stamens numerous (about 100), exserted and spreading, inserted on the margin of the calyx tube; filaments pinkish, 2–6 mm. long, slender, subulate, glabrous, finely glandular-punctate, anthers white, 3–7 mm. long, orbicular-ovate; style terete, subulate, included, 5–6.5 mm. long, glabrous, finely

glandular-punctate; berry oblong to oblong-elliptic, asymmetric 1.5–2.0 cm. long, 1.0–1.5 cm. wide, glabrous, dark purple or black, shiny, minutely glandular-punctate, umbilicate, crowned by the truncate scars of the calyx lobes, umbilicus 1–2 mm. tall, 1.5–3 mm. in diameter; pericarp pulpy, 1.5–3 mm. thick, seed ellipsoid or oblong-ellipsoid, 1.0–1.5 cm. long, 0.5–1.0 cm. wide, seed coat, crustaceous, 0.5–1.0 mm. thick, closely adhering to the subrugose surface of the cotyledons; cotyledons unequal, not fused, conspicuously glandular-punctate.

Common name: Java Plum.

DISTRIBUTION: Widely distributed on all the Hawaiian islands, found in large stands in dry and moist valleys; cultivated, spreading from cultivation, and established. Widely distributed in the Indo-Malayan region and in the tropics of the world.

Specimens examined:

KAUAI: Hanapepe, Koula Valley, 750 ft. alt., on side of road, Dec. 27, 1952, *Wilson 210.*

OAHU: Koolau Mts.: Honolulu, Nuuanu Valley, Dowsett Highlands, by road, Sept. 19, 1943, *Neal.* Waianae Range: Kamananui, Dupont trail on ridge south of Pamoa Gulch, by forest reserve fence, 1500 ft. alt., Sept. 14, 1952, *Wilson 145;* N. of Kaala, naturalized in pasture, April 26, 1937, *Degener 11,902 and 11,903* (NY); Mokuleia, Makaleha Valley, 900 ft. alt., in lowland scrub, Sept. 15, 1950, *Hatheway et al. 357;* Honouliuli, Puu Manawahua, lower woods, 1800 ft. alt., Sept. 29, 1929, *St. John 9,893.*

MOLOKAI: Halawa Valley, 150 ft. alt., spreading along trail, by abandoned, overgrown taro patches, Dec. 27, 1932, *St. John et al. 12,676;* eastern side of Wailau Valley near ocean, naturalized, Aug. 14, 1928, *Degener 9,664* (NY); near Kanalo, naturalized, Aug. 8, 1928, *Degener 7,345* (NY).

MAUI: Wailuku, culta, Aug. 1909, *Faurie 55;* Muolea, E. Maui, 3 miles from Hana, along roadside, Dec. 27, 1951, *Wilson 101;* Ukumehame, Ukumehame Gulch, 800 ft. alt., along bank of stream, Dec. 29, 1951, *Wilson 104.*

HAWAII: Puna, Pahau Nui, alt. about 1700 ft. associated with guava, Aug. 2, 1945, *Fagerlund and Mitchell 1,104;* above Hilo, along Malili stream, homestead, alt. 650 m., *MacDaniels 249.*

Eugenia Cumini is of recent introduction into the Hawaiian Islands. It has rapidly become established and widely distributed, most likely by birds which relish the fruit. It may now be found in abundant stands in the dryer regions of the islands, forming the dominant vegetation of valleys with periodically dry streams.

No record has been found that indicates when this species was introduced into the islands. The earliest collection of it in the Hawaiian Islands was by Faurie on Maui in August 1909. He records it as "Wailuku Culta."

5. **Eugenia uniflora** L., Sp. Pl. 470, 1753.

Shrub 2–3 m. tall, branches greyish-brown, smooth, glabrous; leaf scars 1–1.5 mm. wide, rounded shield-shaped, yellow-brown to reddish-brown; leafy branches green to greyish-brown, glabrous, 1–4 mm. in diameter, angled when young, becoming terete in age; internodes 2–4 cm. long; leaves 4–7 cm. long, 2–4 cm. wide, ovate to ovate-lanceolate, tapering to acuminate apex, base rounded to subcuneate; margin entire, slightly revolute; blade thin coriaceous, above glabrous, shiny yellow-green to dark olive-green, minutely glandular-punctate, below pale yellow-green, glabrous or very sparsely puberulous, minutely glandular-punctate; midrib reddish-green, shallowly impressed above, elevated below; primary lateral veins alternate or opposite, elevated on both surfaces but more conspicuous below, 9–12 on a side, 4–7 mm. apart, irregularly ascending at 140–150°, meeting in an irregularly lobed continuous marginal vein 2–5 mm. from leaf margin; less conspicuous continuous or sometimes interrupted marginal vein 0.5–1 mm. from leaf

margin; the veinlets less distinct, raised-reticulate; petioles 2–5 mm. long, 0.5–1 mm. wide, dark reddish-green, glabrous; flowers single or in pairs, axillary; peduncles 2–4 cm. long, 4-angled or terete, glabrous; calyx tube 2–3 mm. long, 3–4 mm. wide, green, glabrous or sparsely puberulent; calyx lobes 4, persistent, 3–4 mm. long, 3–4 mm. wide, membranaceous, green, ovate with acute apex, ciliate, minutely glandular-punctate, attached to annular disk within the tube; petals 4, white, spreading, persistent, obovate with an obtuse apex, ciliate, 7–8 mm. long, 5–6 mm. wide, sparsely glandular-punctate; annular disk raised 0.5 mm. above point of petal insertion, strigose; stamens numerous (about 50), spreading, inserted on annular disk; filaments 3–7 mm. long, white glabrous, subulate; anthers white, 0.5–1 mm. long, orbicular-ovate; style, terete, subulate, slightly exserted or included, 4–6 mm. long, glabrous; fruit subspherical, red, 1–2 cm. high, 1–2 cm. wide, glabrous, minutely glandular-punctate, crowned by the persistent calyx lobes, conspicuously longitudinally 8-ribbed; pericarp fleshy, 2–3 mm. thick; seed subglobose, 8–15 mm. in diameter, seed coat thin membranous, loosely adhering to the pericarp or to the surface of the cotyledons; cotyledons fused, finely glandular-punctate.

Common name: Surinam Cherry, Pitanga.

DISTRIBUTION: Very sparingly naturalized on the larger islands. Native to Brazil.

Specimens examined:

KAUAI: Lihue, planted, June 10, 1926, *Degener 2,080.*

OAHU: U. S. Expt. Station, Oct. 25, 1926, *MacDaniels 349.*

MOLOKAI: Halawa Valley, 50 ft. alt., shrubs by roadside, Dec. 27, 1932, *St. John et al. 12,665.*

HAWAII: Planted and persisting, April 10, 1930, *Degener 7,331* (NY).

The number of collections of this species is very meager, and future collections should be made to establish the occurrence of it in the Hawaiian Islands.

6. **Eugenia rariflora** Benth., in Hooker's London Jour. Bot. 2: 221, 1843.

Eugenia waianensis Deg., Fl. Hawaii., Fam. 273, 7/15/32.

Eugenia koolauensis Deg. var. *glabra* Deg., Fl. Hawaii., Fam. 273, 8/10/32.

Eugenia rariflora Benth. var. *parvifolia* Hdb., Fl. Hawaii. Is. 129, 1888.

Tree or shrub 3–7 m. tall; branches grey to greyish-white, glabrous, in age the bark greyish-white to greyish-brown, longitudinally and transversely irregularly furrowed; leafy branchlets 1.5–2 mm. in diameter, quadrangular to terete, brown, brown puberulent when young; leaf scars rounded shield-shaped, 1–1.5 mm. wide; bundle scar 1; internodes 0.5–3 cm. long; leaves opposite, 3–7 cm. long, 1.5–5 cm. wide, blade elliptical, ovate or obovate, apex obtuse, acute, retuse or apiculate, base cuneate or rounded, coriaceous, above olive-green, shiny, minutely glandular-punctate, glabrous or sparsely puberulent near midrib, below dull, yellowish-green, minutely pustulate, glabrous or somewhat puberulent at base near midrib; midrib shallowly impressed above, elevated below; primary lateral veins alternate or opposite, 5–3 on a side, 4–8 mm. apart, irregularly or straight ascending at 140–150°, meeting in an irregularly lobed intramarginal vein, 1–2 mm. from leaf margin, raised on both surfaces, but more distinct below; the veinlets raised-reticulate; petioles 2–4 mm. long, 1 mm. wide, brown, glabrous or slightly puberulent; flowers single or in pairs, axillary; peduncles 5–15 mm. long, glabrous or puberulent; calyx tube 2–3 mm. long, 3–4 mm. across, obconic, brown, puberulent, minutely glandular-punctate, subtended by two persistent, subulate sparsely puberulent bracts 1–1.5 mm. long; calyx lobes 4, unequal in length, 1 opposite pair 3–4 mm. long, 3–4 mm. wide, the other pair shorter, 2–3 mm. long, 3–4 mm. wide, ovate, green, fleshy, persistent, below minutely glandular-punctate, glabrous, above glabrous, within the tube attached to annular

disk; petals 4, white, spreading, persistent, 6–8 mm. long, 4–5 mm. wide, inserted on the margin of the disk, ovate, obovate or elliptic, minutely glandular-punctate, membranaceous, ciliate and sparsely puberulous, apex obtuse or acuminate, base truncate; annular disk raised 0.5 mm. above point of petal insertion, glabrous; stamens numerous (about 150), inserted on disk; filaments white, 1.5–5 mm. long, slender, subulate, glabrous; anthers white, 0.5–0.8 mm. long, orbicular-ovate; style terete, subulate, slightly exserted or included, 2–4 mm. long, glabrous; fruit ovoid to subspherical, crowned by persistent calyx lobes, 1–2 cm. high, 1–1.6 cm. wide, glabrous or somewhat appressed-pilosulous, red, orange or yellow, minutely glandular-punctate; pericarp fleshy, 1–2 mm. thick, seed globose, 8–10 mm. in diameter; seed coat thin membranous, closely adhering to the pericarp; cotyledons 2, white or yellowish, minutely glandular-punctate, usually fused, but sometimes only partly fused or entirely free.

Lectotype: "Feejee Islands" (Fiji) *Hinds 1841* (K).

Common name: "Nioi" (Rock, 1913*b*).

DISTRIBUTION: High islands of Polynesia. In the Hawaiian Islands it is found on all the large islands except the island of Hawaii.

Specimens examined:

KAUAI: Hanakoa, 750 ft., Aug. 28, 1926, *Judd 44;* Haupu, Kipu, 800 ft. alt., wooded slope, Dec. 25, 1933, *St. John and Fosberg 13,616;* northeast of Kipu, June 17, 1926, *Degener 7,304* (NY).

OAHU: Koolau Mts.: Waimano, 6–1919, *Russ;* Waimano, E. branch, E. slope above pass, May 29, 1933, *Russ;* Waimano, Oct. 1935, *Meebold* (*Degener 20,768*) (M); ridge between Niu and Wailupe, April 11, 1917, *Forbes 2458.0.* Waianae Mts.: Near Kawaihapai, shaded dry slope, Jan. 27, 1929, *Degener and Bush 7,305* (GH, NY); Mokuleia, Kaaawa (= Kaawa?) Gulch, north of Kaala, dryish forest slope, Aug. 2, 1938, *Degener and Odònez 12,192* (US, NY); Mokuleia, west side of east branch of E. Makaleha stream, 1300 ft. alt., steep talus slope, in dryland forest, Aug. 31, 1950, *Hatheway 376;* Mokuleia, east side of east branch of Makaleha Valley, densely forested slope at 1600 ft., July 2, 1950, *Degener, Hatheway and Greenwell 20,824* (US); Mokuleia, west branch of E. Makaleha Valley, 1800 ft. alt., dry forest on steep valley side, June 11, 1952, *St. John 24,827;* Mokuleia, west branch, E. Makaleha Valley, in small side gulch, 1750 ft. alt., Sept. 30, 1950, *Hatheway 384;* Makaleha Valley, May 2, 1918, *Rock 17,005* (GH); Makaleha Valley, Oct. 23, 1936, *Meebold* (*Degener 21,980*) (M); Mokuleia, gulch southwest of Dillingham Ranch, in shade at 1700 ft., April 23, 1950, *Degener, Hatheway and Carrol 20,615;* Mokuleia, 4th gulch east of Puu Kaupakuhale, Kamananui, Puu Kaala, Oct. 23, 1932, *Yuncker and Hosaka 3,216* (US); half mile southwest of Pohakea Pass, single, dying tree on dry grass and lantana covered slope, July 30, 1932, *Degener and Bush 4,194* (GH); Honouliuli, ridge above Kupehau, dry lantana covered slope, June 30, 1935, *Fosberg 10,995;* Honouliuli, Kanehoa Gulch, dry slope, elev. 700 m., Oct. 12, 1927, *Judd 65;* Honouliuli, between Palehua and Palikea, near summit ridge, Dec. 16, 1935, *Degener et al. 11,300;* third small valley northeast of Palikea (contains pipe line arising from tunnel), dry woods, Sept. 19, 1932, *Degener, Park and Bush 7,303* (GH, MICH, NY); north of Puu Pane, sunny gulch at 200 ft. elev., south of ruin of cathedral, March 26, 1950, *Degener and Carroll 20,581* (US); on firebreak trail 1 m. north of Puu Kaua, 1700 ft. alt., on dry slope, Sept. 5, 1952, *Wilson, St. John and St. John 143;* on firebreak trail, 1 m. N. of Puu Kaua, alt. 1700 ft. on dry slope, Feb. 29, 1948, *Cowan 843;* Kahanahaiki, 234 m. alt., dry river bottom, Oct. 16, 1925, *Judd 23;* southern slope of Kahanahaiki Valley, dry forest, Nov. 1, 1931, *Degener et al. 7,296* (GH, MICH, NY); Makua Valley, May 1930, *Russ;* small gulch on south side of upper Makua Valley, dry forest, May 10, 1931, *Degener, Park and Bush 7,295* (GH, NY); Waianae, Feb. 1930, *Meebold 8,629*

(M); U. S. Explor., Exped., highland near Waianae; large branch of Lualualei Valley, southwest of Pohakea Pass, Aug. 4, 1932, *Degener and Bush 7,299* (NY).

No locality: Collect. Dr. Hillebrand, Oahu, Maui (GH).

MOLOKAI: Central Molokai, wet forest, Oct. 13, 1916, *Hitchcock 15,193* (US).

MAUI: Olowalu Valley, May 19, 1920, *Forbes 2417.M* (US); Wailuku, W. Maui, *Hillebrand and Lydgate.*

Eugenia rariflora was first recorded for the Hawaiian Islands by Hillebrand in 1888. It occurs occasionally in the drier regions of the larger islands except Hawaii. This species shows considerable variation in its leaves although not to as great a degree as *E. sandwicensis.*

Both *E. waianensis* and *E. koolauensis* var. *glabra* are here reduced to *Eugenia rariflora* because of intermediate forms which make it impossible to set definite limits upon the two.

The concave leaves would be the only character which would separate *E. koolauensis* var. *glabra* from *E. rariflora.* But a collection from Palikea, Oahu (*Degener 7,303*) has leaves which are only slightly concave; another specimen (*Degener 20,581*) shows leaves that are more strongly concave. This character is certainly not a reliable one, and is of no taxonomic value in this case. This conclusion is supported by the fact that the characters of *E. koolauensis* var. *glabra* are identical in all other respects with those of *E. rariflora.*

The size of the leaves of *E. rariflora* might seem to offer a remarkably valuable taxonomic character, particularly when the extremes in form are considered. *E. waianensis* is described as differing from *E. rariflora* in having smaller leaves. This character seems to be of value when specimens with extremely small leaves are studied (*Degener 7,296*). However, some specimens, such as those collected by Forbes (*2417.M*) and Rock (*17,005*), have leaves which show a series of intermediate sizes between *E. waianensis* and *E. rariflora.* In such cases this character proves to be of little value.

7. **Eugenia koolauensis** Deg., Fl. Hawaii. Fam. 273, 8/10/32.

Tree 4–7 m. tall; branches grey, glabrate, in age the bark reddish-brown, black spotted; leaf scars 1–2 mm. wide, rounded shield-shaped, reddish-brown; leafy branchlets 1–3 mm. in diameter, 4-angled to terete, densely brown subappressed-pilosulous; internodes 9–19 mm. long; leaves 2.5–5 cm. long, 1–3.3 cm. wide, obovate to elliptic, apex obtuse or apiculate, base subcuneate, blade coriaceous, concave, margin entire, more or less strongly revolute, above olive-green, minutely glandular-punctate, glabrous and shiny or subappressed-pilosulous near veins with intervals glabrous, below pale yellowish-green, minutely pitted or pustulate, subappressed-puberulent; midrib shallowly impressed above, elevated below; primary lateral veins, alternate or opposite, 5–7 on a side, 5–10 mm. apart, irregularly ascending at 140–150°, meeting in an irregularly lobed intramarginal vein 1–2 mm. from leaf margin, raised on both surfaces but more distinct below, rarely slightly shallowly impressed above; the veinlets raised-reticulate; petioles 2–4 mm. long, 1 mm. wide, brown subappressed-pilosulous; flowers single or in pairs, axillary; peduncles 1–8 mm. long, subappressed-pilosulous, bracteate; bract subulate, yellow-brown subappressed-pilosulous, 1 mm. long, 1 mm. wide; calyx tube obconic, 2–3 mm. long, 3–4 mm. across, subappressed-pilosulous, subtended by two persistent subulate brown subappressed-pilosulous bracts 1–1.5 mm. long; calyx lobes 4, of unequal length, 1 opposite pair 3–4 mm. long, 3–4 mm. wide, the other pair 2–3 mm. long, 3–4 mm. wide, ovate, green, fleshy, persistent, below finely yellow glandular-punctate, appressed-puberulous, above glabrous, within the tube attached to annular disk; petals 4, white, spreading, persistent, inserted on margin of disk, concave, ovate or obovate or elliptic, apex subacute or obtuse, base truncate, 6–8 mm. long, 4–5 mm. broad, membranaceous, minutely glandular-punctate, ciliate and sparsely puberul-

ous; annular disk raised 0.5 mm. above point of petal insertion, puberulent; stamens numerous (about 150), inserted on disk occupying 0.5 mm. of the marginal region; filaments white, 1.5–5 mm. long, slender, subulate; anthers white, 0.5–1.0 mm. long, orbicular-ovate; style terete, subulate, slightly exserted or included, 2–4 mm. long, sparsely pilose; ovules 8 in a cell, berry ovoid and asymmetric, 1.2–2.0 cm. high, 1.2–1.6 cm. wide, sparingly appressed-pilosulous, light orange-yellow, shiny, minutely yellow glandular-punctate, crowned by the persistent calyx lobes; pericarp fleshy, 1–2 mm. thick; seed globulose, 8–9 mm. in diameter; seed coat thin, membranous, closely adhering to the pericarp and free from the surface of the cotyledons; cotyledons either completely fused or only partly so, or entirely free.

Type: Oahu, "Northern slope of Kaipapau Valley," *Degener and Park 4,169* (BISH).

DISTRIBUTION: Endemic to the island of Oahu.

Specimens examined:

OAHU: Koolau Mts.: Pupukea, dry gulch side, Sept. 28, 1925, *Judd 20;* Pupukea, elev. 300 m., Nov. 2, 1925, *Brown 1, 274;* Kahuku, entrance of Pupukea-Kahuku trail, lower edge of decadent dry forest among lantana, Nov. 22, 1931, *Degener, Park, and Kwon 7,297* (BISH, NY); Laie, Kahawainui Gulch, elev. 100 m., March 2, 1928, *Judd 71;* Hauula, Papali Gulch on trail, March 1933, *Judd;* Hauula, on top of small cliff, elev. 160 m., Sept. 8, 1926, *Judd 54;* Kaipapau, northern slope of Kaipapau Valley, moderately dry woods near top of ridge, Oct. 11, 1931, *Degener and Park 4,169;* Waimea, N. fork of Kamananui stream, very steep, north facing valley wall, alt. 750 ft., April 16, 1949, *St. John 23,683*, and Sept. 5, 1952, *Wilson, St. John and St. John 142*, and Nov. 18, 1952, *Wilson and Lamberton 163;* gully having prominent dyke, north-north-east of Puu Kamaohanui, Dec. 11, 1932, *Degener 7,302* (NY).

Closely related to *Eugenia rariflora*, *E. koolauensis* may be clearly differentiated by its distinctly concave leaves which have subappressed puberulence on the lower laminar surface. It is a rare species and occurs in the rain forest of the Koolau Range on Oahu.

8. ***Eugenia molokaiana*** K. Wilson and J. F. Rock, sp. nov.

Figs. 1 and 2

Arbor 2.5–3 m. alta, ramulis foliosis 0.5–1.5 mm. diametro manifeste tetragonis usque teretibus, crebrissime brunneis subadpressi-pilosulis, internodis 7–24 mm. longis, foliis oppositis 2.0–3.0 cm. longis, 1.4–2.0 cm. latis, suborbicularibus, ellipticis vel obovatis, apice obtuso vel apiculato rare retuso, basi subcuneato, laminis coriaceis concavis, margine integris valde revolutis, supra olivaceis minute pustulatis novellis dense subadpressi-pilosulis, in aetate nitidi-glabrescentibus, subtus pallide flavidi-viridibus minute glandulosi-punctatis dense subadpressi-puberulentibus, petiolis 1–3 mm. longis 1 mm. latis dense brunneis subadpressi-pilosulis, floribus solitariis in bracteorum axillibus, bracteis subulatis dense brunneis subadpressi-pilosulis 1–1.5 mm. longis 1 mm. latis, pedunculis 5–7 mm. longis 0.5 mm. latis subadpressi-pilosulis, calycis tuba 2–3 mm. longa 3–4 mm. diametro subadpressi-pilosula, a 2 bracteis persistentibus subulatis brunneis subadpressi-pilosulis subtensa, bracteis 1.5–2.0 mm. longis, calycis lobis 4 ovatis viridibus carnosis persistentibus longitudine inaequalibus, quorum uno jugo opposito 2 mm. longo 2 mm. lato, altero 3 mm. longo 2 mm. lato, petalis 4 albis in disci annularis margine insertis ovatis vel obovatis 4 mm. longis 3 mm. latis membranaceis ciliatis, apice obtuso, basi truncato vix puberulo minute glandulosi-punctato, pistillo tereti subulato 2–5 mm. longo basi dense puberulenti supra glabroso, stigmati peltato, fructibus ovoideis symmetricibus in sicco 8 mm. diametro dense adpressi-pilosulis rubris insigniter flavidi-glandulari-punctatis calycis lobis persistentibus coronatis.

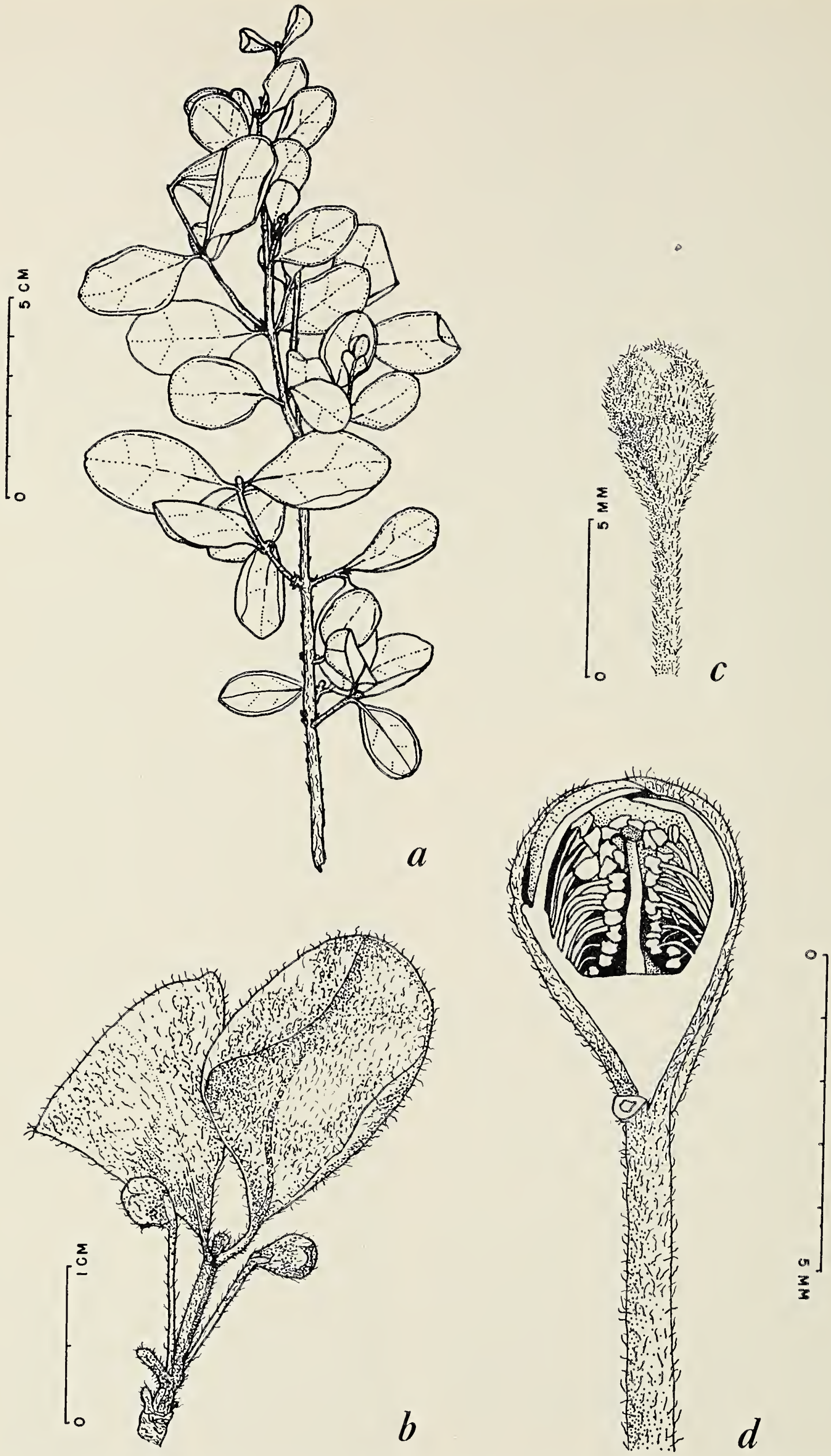

FIG. 1. *Eugenia molokaiana*. *a*, Habit × .50; *b*, flower bearing branchlet × 2; *c*, bud × 4; *d*, dissected flower bud × 8. From Rock 17,144B.

Tree 2.5–3 m. high; branches greyish-brown, glabrate, in age the bark smooth yellowish-red; leaf scars 1–1.5 mm. wide, rounded shield-shaped, reddish-brown; leafy branchlets 0.5–1.5 mm. in diameter distinctly 4-angled to terete, densely brown subappressed-pilosulous; internodes 7–24 mm. long; leaves 2.0–3.0 cm. long, 1.4–2.0 cm. wide, suborbicular, elliptic or obovate; apex obtuse or apiculate, rarely retuse, base subcuneate; blade coriaceous, concave, margin entire, strongly revolute, above olive-green, minutely pustulate, densely subappressed-pilosulous when young, becoming glabrous and shiny in age, below pale yellowish-green, minutely glandular-punctate, densely subappressed-puberulent; midrib shallowly impressed above, elevated below, primary lateral veins alternate or opposite, 5–7 on a side, 4–9 mm. apart, irregularly ascending at 140–150°, meeting in an irregularly lobed intramarginal vein 1.0–1.5 mm. from leaf margin, raised on both surfaces but more distinct below, the veinlets less conspicuous, raised-reticulate; petioles 1–3 mm. long, 1 mm. wide, densely brown subappressed-pilosulous; flowers single, in the axils of bracts; the bracts subulate, densely brown subappressed-pilosulous, 1–1.5 mm. long, 1 mm. wide, peduncles 5–7 mm. long, 0.5 mm. wide, subappressed-pilosulous; calyx tube 2–3 mm. long, 3–4 mm. across, subappressed-pilosulous, subtended by two persistent subulate, brown, subappressed-pilosulous bracts; the bracts 1.5–2.0 mm. long; calyx lobes 4, ovate, green, fleshy, persistent, of unequal length, 1 opposite pair 2 mm. long, 2 mm. wide, the other pair 3 mm. long, 2 mm. wide; petals 4, white, inserted on margin of annular disk, ovate or obovate, 4 mm. long, 3 mm. wide, membranaceous, ciliate, apex obtuse, base truncate, sparsely puberulous, minutely glandular-punctate; stamens numerous (about 150); filaments white, 0.5–2.0 mm. long, slender, subulate, glabrous; anthers white, orbicular-ovate, 0.2–0.5 mm. long; style terete, subulate, 2.5 mm. long, densely puberulent at base, glabrous above; stigma peltate; fruit ovoid, symmetrical, 8 mm. in diameter (when dry), densely appressed-pilosulous, red, conspicously yellow glandular-punctate, crowned by the persistent lobes of the calyx.

Type: Hawaiian Islands, Molokai: Maunaloa; June 1918, *J. F. Rock 17,144*, in the Bernice P. Bishop Museum Herbarium.

Common name: "Nioi."

DISTRIBUTION: Known only from the type locality, Maunaloa, Molokai, and now probably extinct.

Specimens examined:

MOLOKAI: Maunaloa: April 1918, *Rock 17,144;* June 1918, *Rock 17,144;* Feb. 1920, *Rock 17,144B* (BISH, GH).

Eugenia molokaiana is known only from the collections made by Rock at Maunaloa, Molokai. When the locality was first visited in 1918, Rock photographed the tree which was then already dying (Fig. 2). Since 1920 there has not been a single subsequent collection of this species. In 1953 Rock was fortunate in being able to revisit Maunaloa, Molokai, in search of this tree. Unfortunately there is no longer any trace of its existence. *E. molokaiana* has disappeared, like many other trees from that locality.

If ever it should be found, *E. molokaiana* may be easily recognized by its small red fruits, its peltate stigma, and its small, concave, pubescent leaves.

The description of the flower is based on a bud just before anthesis. Unfortunately no open flowers have been seen. The nature of the embryo and seed are not known since it did not seem advisable to dissect the single fruit which was available.

Miss Marie C. Neal informs us that the *nioi* growing on Maunaloa, Molokai, was one of three trees of that region which played an important role in Hawaiian traditions. According to the notes in the Bishop Museum on the native Hawaiian names of plants, the *nioi* from Maunaloa, Molokai, was identified as "the tree form of a god, Kane-ikaulana ula." The tree was used for making images

FIG. 2. *Eugenia molokaiana* growing on Maunaloa, Molokai. (Photo by J. F. Rock.)

by the command of the chiefs, or parts of it were used in "vicious sorcery." The *nioi* growing on Maunaloa was also claimed to be poisonous (Neal, letter). If our identification of this *nioi* as *Eugenia molokaiana* is correct, then we can attribute the belief of its toxicity only to superstition.

TAXA REQUIRING FURTHER STUDY:

Episyzygium oahuense Suesseng. and Ludw., Bot. Staatsaml. München, Mitt. 1: 10, 1950.

The genus *Episyzygium* is based on a single specimen which was collected by A. Meebold in the Waianae mountains in 1930, [A. Meebold 8,445 (M)]. I believe that the peculiar 4-loculed ovary is most likely an abnormality of *Eugenia sandwicensis*. Until such a time that additional corroborative material is collected, I feel that the genus *Episyzygium* and the species *Episyzygium oahuense* should be considered as being based on an aberrant individual.

Hillebrand (1888), Rock (1913), and Degener (1932–34) all reported a rare white form of *Eugenia malaccensis* (*Jambosa malaccensis* f. *cericarpa* Deg.). I have not been able to locate any specimens of this form.

REFERENCES

Airy Shaw, H. K. 1949. Additions to the flora of Borneo and other Malay Islands. XX. *Kew Roy. Bot. Gard. Bul. Misc. Inform.* 1: 117–125.

Alston, A. H. G. 1931. In Trimen, H. *A Handbook to the Flora of Ceylon*. Part 6 (supplement). vi + 350 pp. Dulau & Co., London.

Amshoff, G. J. H. 1942. Notes on the Myrtaceae of Surinam. *Bot. Mus. Univ. Utrecht, Meddel.* 86: 147–165.

Backer, C. A. 1945. Notes on the Flora of Java. *Blumea* 5(3): 490–524.

Bentham, G. 1843. Enumeration of plants collected by R. B. Hinds, Esq., and by Mr. Barclay in the Feejee Islands, Tanna, New Ireland, and New Guinea; to which are added a few species gathered in Amboyna by Mr. Barclay. *Hooker's Lond. Jour. Bot.* 2: 211–240.

Dadswell, H. E., and H. S. Ingle. 1947. The Wood Anatomy of the Myrtaceae, I. *Trop. Woods* 90: 1–7.

De Candolle, A. P. 1828. *Prodromus systematis naturalis regni vegetabilis*. Vol. 3: 1–494. Paris.

Degener, Otto. 1932–1934. *Flora Hawaiiensis*, fam. 273; *Eugenia waianensis*, July 15, 1932; *Eugenia koolauensis*, Aug. 10, 1932; *Jambosa malaccensis*, June 14, 1933; *Jambosa Jambos*, April 20, 1934.

Degener, Otto, and A. Ludwig. 1952. *Syzygium oahuense* sp. nov. *Bot. Staatsaml. München, Mitt.* 4:113.

Gaertner, Joseph. 1788. *De Fructibus et Seminibus Plantarum*. Vol. 1: 182 + 384. 79 pls. Stuttgart.

Gray, Asa. 1854. Botany, Phanerogamia. Vol. 1 *United States Exploring Expedition during the years 1838 . . . Charles Wilkes, U.S.N.* 15: 1–177. Off. ed. C. Sherman, Philadelphia.

Henderson, M. R. 1949. The Genus *Eugenia* (Myrtaceae) in Malaya. *Gard. Bul. Singapore* 12(1): 1–293.

Hillebrand, William. 1888. *Flora of the Hawaiian Islands*. 96 + 673, frontispiece, 4 maps. C. Winter, Heidelberg.

Ingle, H. G., and H. E. Dadswell. 1953. The Anatomy of the Timbers of the South-West Pacific Area. III. Myrtaceae. *Austral. Jour. Bot.* 1(3): 353–401, 10 pls.

Lamarck, J. B. A. P. M. de. 1789. *Encyclopedia méthodique. Botanique*. Vol. 3: viii + 759. Paris.

Lanjouw, J., and F. A. Stafleu. 1954. Index Herbariorum Part I. 2nd ed. *Regnum Vegetabile* 2: 1–179.

Linnaeus, C. 1753. *Species Plantarum*. Ed. 1. 1200 pp. Stockholm.

Merrill, E. D., and L. M. Perry. 1938*a*. On the Indo-Chinese Species of *Syzygium* Gaertner. *Arnold Arboretum, Jour.* 19(2): 99–116.

——— 1938*b*. The Myrtaceae of China. *Arnold Arboretum, Jour.* 19(3): 191–247.

——— 1939. The Myrtaceous Genus *Syzygium* Gaertner in Borneo. *Amer. Acad. Arts and Sci., Mem.* 18(3): 135–202.

MILLSPAUGH, C. F. 1900. Plantae Utowanae. *Field Columb. Mus., Bot.* 2(1): 1–110.

NIEDENZU, FRANZ. 1893. Myrtaceae. In Engler, A. and K. Prantl. *Die Natürlichen Pflanzenfamilien* 3(7): 78–86. W. Engelmann, Leipzig.

ROCK, J. F. 1913*a*. *The Indigenous Trees of the Hawaiian Islands.* iv + 518 pp. 215 pls. Honolulu.

——— 1913*b*. List of Hawaiian Names of Plants. *Ter. of Hawaii, Bd. Agr. and For. Bot. Bul.* 2: 1–20.

SKEELS, H. C. 1912. In: Seeds and Plants Imported during the Period from July 1 to September 30, 1911. *U. S. Dept. Agr. Bur. Plant Indus. Bul.* 248: 25.

SUESSENGUTH, K., and A. LUDWIG. 1950. Myrtaceae. *Bot. Staatsaml. München, Mitt.* 1: 10.

WHITE, C. T. 1945. Contributions to the Queensland Flora No. 9. *Roy. Soc. Queensland, Proc.* 57: 21–36.

Origin and Diffusion of the Herzberg Principle with Especial Reference to Hawaii[1]

HAROLD S. PALMER[2]

WHEN IT BECAME KNOWN in Hawaii that successful artesian wells had been sunk in many parts of California, various people discussed the question whether artesian water existed in Hawaii. Certain optimists brought a capable well driller from California in 1876, but were emphatically rebuffed when they sought financial help from the government. According to H. M. Whitney (1898), the decision lay with the Finance Minister, who refused money for a test well because he held that all "caverns" below sea level were filled with salt water, and that any rain water reaching the caverns became salt water at once. How wrong he was appeared just three years later when James Campbell, at his own expense, had a good well drilled in Honouliuli.

As more wells were drilled, it was learned that holes near the sea or near the axes of valleys were apt to be failures. We have no evidence as to how well the hydrologic conditions were understood. In 1882 Judge McCully described the successes to that date. Appended to his article is some material by an unnamed writer, who thought correctly that the fresh water was prevented from escaping to the sea by impervious strata, which he called "very compact clay." This, certainly, is a very important factor in the modern explanation of the artesian conditions in Honolulu.

Schuyler and Allardt concluded in 1889 that the Pearl Harbor Springs and the artesian wells drew from the same source of supply, as shown by the fact that water rose in the artesian wells only a little higher than the highest springs. They wrote, "The probabilities are that the island is surrounded by deep thick strata of impervious clay . . . , that these strata lap onto the land to the height the water rises in wells, . . . and that these strata prevent the escape of the waters into the sea beneath them." They seem to be the first to point out the relation between the height of what we now call "cap rock," and the artesian level. A diagrammatic cross section illustrates their views to some degree. Unfortunately their report was a private affair and was not widely circulated, one supposes, so that their understanding of the extensive "basal ground water body," as we now call it, was not utilized by others.

In 1875, Franklin C. Hill told how good water could be gotten by digging shallow wells in sand islands off the Gulf Coasts of Mississippi and western Florida. He explained the presence of fresh water by analogy to an "ash leach," a vessel, such as a barrel, tight enough to hold wood ashes but with small openings at the bottom through which liquids could escape. Hot water poured in on top of the wood ashes leaches out potassium salts, sinks downward and out at the bottom. As more and more water is added it drives the previous lots of water downward with little mixing. Hill draws a parallel with water from rain driving salt water down to some depth

[1] The Herzberg principle holds that in oceanic islands and along shores of larger land masses fresh water floats on and is underlain by sea water because of their differences in density.

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on sand islands making what he called a "lake of fresh water held by the sand in the midst of the sea." He shows that with a porosity of one-third, a 12-foot layer of sand is equivalent to a lake 4 feet deep, and that an acre would hold about one and a quarter million gallons. He seems not to have considered the relative densities of fresh and salt water or of pure water and water holding potassium salts in solution.

In the next decade much progress was made in Europe. In 1888–89, W. Badon Ghyben, a Captain of Engineers in the Netherlands Army, as a result of studies near Amsterdam, found fresh water under the coastal dunes and resting on salt water, and observed that the depth to the salt water increased inland from the shore. He assumed that the specific gravity of North Sea water was 1.0238, from which he calculated that the depth below sea level to salt water was about 42 times the height of fresh water above sea level (1.000/ 0.0238 = 42.01).

A better exposition of the idea was published by Alexander Herzberg in 1901, based on studies on the island of Norderney. A hole was drilled near the middle of the island to learn about its geologic structure. Cox's translation reads, "It could not be doubted after these observations that the fresh water floated on the subterranean salt water." In another place we read, "The deep position of the sea-water boundary is a function of the height of the ground water table in the dunes above mean tide level in the sea." Herzberg used 1.027 as the specific gravity of North Sea water and from it calculated that the sea water boundary was 37 times as far below sea level as the water table was above sea level. Although Herzberg did not publish until 1901, he seems clearly to have made use of the principle as early as 1889, or even 1886, in his work as a consulting hydrologic engineer.

After Herzberg's publication, there was much discussion of the details of the principle by Dutch, Belgian, French, and German workers.

According to Watson (1956), the early Hawaiians had gotten water from small, shallow wells dug near the shore. Between 1894 and 1900 Maui plantations made thirteen large-scale basal water developments which were gigantic forms of the shallow wells of the early Hawaiians. These were large pits sunk from ground heights of 20 to 50 feet, and large volumes of water were pumped by great steam pumps. These installations had two bad features. For one thing the water was rather saline because the fresh water lens was thin in the absence of a cap rock. Secondly, a very long pipe line was needed to carry the water to the cane fields.

In 1899, Henry Perrine Baldwin and his consulting engineer, Herman F. A. Schussler, believed that fresh water extended far inland under central Maui, as what we now call the "basal ground water body." A shaft (H. C. & S. Co.'s "Kihei," No. 3) was sunk about three miles from the shore from a height of 303 feet. The shaft was 323 feet deep and the water table was 6 feet above sea level. Skimming tunnels were driven close to sea level and a large supply of irrigation water was obtained. This was the first "Maui-type basal water development," and has been followed in Hawaii by more than 50 others of the same general type.

Thus it is clear that in the Hawaiian sugar industry the existence of the great basal ground water body was known, even though it had not been satisfactorily explained.

Waldemar Lindgren spent part of 1901 on Molokai, and wrote (1903):

> In the absence of any impermeable stratum or basins filled by clayey materials, such as, for instance, exist on Oahu, there is nothing to prevent the sea water from entering the rocks freely and assuming a level differing but little from sea level. Below a certain level there is no reason to expect anything but sea water.
>
> On the other hand, the rain water also sinks freely through the porous rocks until it meets the sea water. Here, at the permanent water level it is held by the counter pressure of the sea water, and in fact rests like a sheet upon the

same. Between the underlying salt water and the fresh water on top of it there is an intermediate zone of varying width in which the two mingle to form brackish water. The fresh water, always receiving additions from above, is slowly but steadily moving to the only outlet it can find —that is, to springs located along the sea shore, just above or a little below sea level.

The surface of the salt water "is . . . about 160 feet below the surface of the ground [near the south shore]. Inland this level sinks. . . . The permanent surface of fresh water rises inland very slowly, so that a mile or more inland the water in wells may stand only a foot or two above sea level."

Attention is called to Dr. Lindgren's reference to the "counter pressure of sea water," and to his observation that the water table rose inland and that the salt-fresh boundary dropped inland. He was very close to developing the idea of the fresh water lens.

In the following years a number of studies were made by members of the U. S. Geological Survey in states bordering the Atlantic and Gulf Coasts.

Harris in 1904 held that fluctuations of water levels in wells in Louisiana were responses to loading and unloading of impermeable strata over the water-bearing strata by tides and by strong onshore winds. Also, that the fluctuations did not depend on any direct connection between the water of the Gulf and the water in the artesian aquifers.

Pennink in 1904 discussed before the International Engineering Congress in St. Louis some of the features of the relationship between fresh and salt water under coasts and islands, based on his work in the Netherlands. Unfortunately the title of the paper (1905) did not reveal this topic, so that it did not come to the attention of geologists. It is not nearly as forthright a presentation of the Herzberg principle as one would wish.

Veatch and others (1906), in a big report on the ground waters of Long Island, N. Y., made no reference to any possible relationship between fresh and salt water. Twelve north-south profiles of the island and its water table have as their bases the line 20 feet below sea level. Curiously these profiles have the pattern for the saturated zone extend out under both the north and south shores, as if fresh water extended under the waters of the bays at the south and those of Long Island Sound on the north. It would seem, therefore, that they gave no consideration to the effect of salt water.

Veatch in 1906, in a smaller paper, wrote that the water level under Long Island coincided with sea level at the shores and became higher inland, but said nothing about any underlying salt water.

Taylor, writing in 1907 of the salinity of some wells in the Texas Coastal Plain, offered no explanation of the salinity.

We now come back to Hawaii again, for in 1908 W. D. Alexander discussed the ideas ascribed to McCully and wrote that McCully (really some unnamed person) held that "it seems evident that the great central stratum of water-bearing rock must be completely surrounded by impervious strata from the surrounding ocean. Were it not so, the water it contains would escape into the sea instead of standing at forty-two feet above it." Alexander agreed with most of these ideas, but not entirely, for he wrote, "On the whole the theory . . . seems . . . to be the most probable one, although it may not be necessary to assume that the 'water-bearing rock must be completely separated by impervious strata from the ocean,' in view of the slowness with which water percolates through rock and gravel, and also of the pressure of the sea water." Unfortunately Alexander did not develop the germ of the idea further, perhaps because not more than 23 well logs could have been available to him then.

It remained for Andrews, in 1909, to make a tremendous advance in the understanding of the artesian system at Honolulu. Like McCully's ghost writer and Alexander, he thought the barrier of "clay" played an important role, but he developed the all-important part played

by the balance between salt and fresh water. He wrote, "The water-bearing stratum is the lava of the volcanic dome as it was finally completed by the upbuilding volcanic forces. The water-bearing lava rock is covered with a layer of clay, the product of decomposition of lava, which in turn, is covered with a stratum of coral rock, formed as a fringing reef, above which strata of coral and volcanic material may alternate. The depth below sea level to which the retaining clay stratum would need to extend in order that fresh water in wells should be raised forty-two feet above sea level by the hydrostatic pressure of sea water of density 1.026, is 1614 feet, which is but little deeper than the depths at which clay was found in the deeper wells." (The 1.026 specific gravity for sea water would give a ratio of 38.5 between the depth to sea water and the height of fresh water: 1.000/0.026 = 38.46.)

"An arrangement of coral and clay strata such as here presented fully accounts for the phenomenon of flowing wells on an island of volcanic origin. The lava of the volcanic dome is somewhat porous, penetrated by cracks, and open enough to permit the movement of water; the clay stratum overlying the lava prevents the escape of water upward; the remaining coral and clay strata simply add an overlying mass, and the elevation of the uppermost coral layer above sea level, lined as it is by clay, raises the surface of the underground water accumulations until they escape as springs over the coral brim, or rise above sea level in artesian wells to the height of escape."

Thus it appears clear that Andrews, who had no knowledge of the work done in Europe on coastal ground waters, entirely independently worked out what we now call the "Herzberg Principle." On Dec. 24, 1955, I called on Professor Andrews and we discussed the matter at some length. Apropos of statements sometimes made that Andrews got his ideas from the Alexanders (plural), he told me that Arthur C. Alexander merely transmitted his father's idea that sea water exerted a pressure. Working out mathematically the ratio of the depth to salt water to the height of the water table, as a function of the relative densities of the two liquids was entirely Andrews' idea. Thus Professor Andrews seems clearly to be the first American to give a mathematical expression of the ratio.

Andrews' remarkable insight into the phenomena is also shown by his correctly explaining the so-called "clay," which acts as the restraining member, as the impermeable residual matter due to very advanced weathering in place of the upper or outer parts of the body of lavas. Others had thought that the clay originated as some sort of marine sediment at a time when the sea reached higher on the island. It is hard to think that clay, in water, would remain in place on steep submarine slopes.

It is most unfortunate that Andrews' paper was never printed, for in its typescript form it gained only moderate circulation.

In 1908 Gregory and Ellis described fluctuations of water levels in wells near the Connecticut shore, but did not refer to the density of sea water. They reported one well in Norwalk that had fresh water to a depth of 50 or 60 feet in sand, but only salt water at lower levels. Plugging of the bottom of the well shut off the salt water successfully.

Clapp, also in 1909, reported on conditions in southern Maine, where salt water had been found under fresh water in a good many wells near the shore, but he made no mention of the density of sea water. A typical well in Islesboro, "obtained good water at 181 feet from the surface, but drilling continued, and at 220 feet salt water was encountered. The well was filled with Portland cement to a depth of about 200 feet from the top, the sea water being thus shut off, and the water was reported of good quality in 1906."

Hitchcock, in 1910, in an address to a Special Conservation Meeting held in Iolani Palace, told of the lava rock aquifer and the cap rock of the artesian system. He made some use of Alexander's idea of the pressure

of sea water, but made no reference to Andrews' thorough and invaluable development of that idea. This omission by Hitchcock may be taken to illustrate the unfortunately limited circulation of Andrews' paper.

We next go back to Long Island, where Spear in 1912 applied the Herzberg principle, I think for the first time in any American ground water study. He mentions some of the studies made in Europe, and gives a diagrammatic cross section of the lens under a simple island. He shows the derivation of the "40 to 1" ratio where the specific gravity of sea water is 1.025, and also other ratios for other densities of sea water. A diagrammatic cross section of Long Island is given, in which the base of the fresh water lens is truncated by a smooth basement of impermeable rock instead of making the full downward curve. The principle was used by Spear in forecasting the behavior of wells in certain localities.

Unfortunately for geologists, Spear's work was published in an engineering report for the New York Board of Water Supply, which few geologists would be apt to read.

In 1912 the first edition of Keilhack's "Lehrbuch der Grundwasser- und Quellenkunde" was published. It was followed in 1917 by an enlarged and revised edition, pages 162 to 165 of which give an excellent presentation of the work of Badon Ghyben and Herzberg, and others. One cross section shows the conditions in an ideal, symmetrical, homogeneous, permeable, and rainy oceanic island. The University of Hawaii Library received a copy of the second edition as early as 1921, but it has been little used.

Matson and Sanford in 1913 came close to the idea of a lens of fresh water under Florida. Florida, of course, differs greatly from Hawaii in its rock types, structure, shifts relative to sea level, and its hydrology.

One earlier geologist had thought that the fact of finding fresh water in marine limestones to a depth of a thousand feet implied a former uplift of Florida by a thousand feet, but Matson and Sanford pointed out that the uplift need not have been more than enough to give a small hydrostatic pressure. Thus, they had come close to the Herzberg principle, as is also shown by the following quotations.

> The rocks of Florida are all sedimentary and for the most part were deposited beneath the ocean. Such deposits are called marine and originally included sea water, which may be called water of deposition. This included sea water may be gradually displaced by descending rain water—the rate of change depending on the freedom of drainage. Where the rocks are porous and the land high the water of deposition is soon removed, but a low altitude combined with dense rocks gives a very slow rate of escape. The process of removal may extend to some distance below sea level provided porous materials emerge on the bottom of the ocean. The exact depth will be controlled by the relative weights of the columns of fresh water beneath the land and the salt water at the point of emergence.
>
> The greater height of the column of fresh water is partly offset by the increase of weight of the sea water caused by its high mineral content and by the friction of the water in the rocks. There must inevitably be a level where the opposing forces counterbalance each other and the underground water becomes nearly static. Below this level the water of deposition is scarcely disturbed.

This was certainly an approach toward the Herzberg principle.

A well at Sumterville, far from the shore, found no salt water though it reached a total depth of nearly 2,000 feet.

Another quotation from Matson and Sanford makes an approach to the idea of a lenticular body of fresh water, and is as follows:

"In passing from the interior of the State toward the coast the depth to salt water diminishes until in many places it may be encountered within less than 500 feet of the surface, though the depth to the strong brines is usually somewhat greater." This passage suggests the downward curve of the lower side of an ideal lens, but does not mention

the corresponding upward curve of the water table or top of the lens.

In 1916 Palmer (1920) thought that the gneiss of Long Neck Point, in Darien, Connecticut, had important joints striking about north and south, parallel to the length of the peninsula, and dipping steeply westward. Wells drilled on the west side of the peninsula got fresh water, but those on the east side got only salt water, which was presumably led into them from the Sound by the westward dipping joints.

In the fall of 1919, Palmer (1919) studied the ground waters of Peaks Island in the harbor of Portland, Maine. The island of 800 acres has a discontinuous mantle of glacial till over schists, whose joints are the main source of ground water. The seven drilled wells on the island extended 3, 105, 110, 110, 146, 166 and 276 feet, respectively, below sea level. The chloride contents of the waters of only five were determined and ranged from 17 to 21 parts per million of water. A slight approach to the Herzberg principle is indicated by the following passage, "The zone of active circulation on Peaks Island is probably entirely above sea level except where it is stimulated by the draft of deep wells. There is probably a more or less conical body of fresh water underlying the island, the point of the cone downwards. The limit of this cone is determined by a balance between fresh water originating on the island and the salt water trying to work under the island." From a 1956 point of view it would have been better to have referred to a "conical region in which the joints contain fresh water," and still better to have used "dome" or "bowl" instead of "cone."

A typescript report by Palmer in 1921 for the Bernice P. Bishop Estate dealt with Maunalua, Oahu. This considered the restraining effect of cap rock where it is present, but made no reference to the density of sea water.

In 1919 the field work of Brown, on the relation of sea water to ground water along coasts, led to two papers that are important landmarks in our story. In a first, smaller paper Brown (1922) introduced to American geologists the work of Badon Ghyben and especially that of Herzberg. Besides giving the formulas and their derivation he reproduces Herzberg's cross section of Norderney and also gives diagrammatic sections of the conditions under an ideal, permeable island and along a permeable coast. There is also reproduced a cross section from a Dutch paper by Pennink of a dune ridge on the Holland coast with isochlors outlining the somewhat lenticular body of fresh ground water.

In the fall of 1955 I wrote Dr. Brown asking how he came across the writings of the European workers. His reply was, "As I recall, I deliberately instituted a search of literature in the Library of Congress on Holland's water problems, on the hunch that that should provide illuminating data, due to the coastal dune belt. This led me on to Badon Ghyben. Somewhere later . . . I ran across a reference to Herzberg."

In 1923, Meinzer's *The Occurrence of Ground Water in the United States* was published. This makes no reference to the Herzberg principle. In one place it points out that, where ground water is found in joints, there is more danger of salt invasion if joints dip landward than if they dip seaward. In another place, apropos of the water-bearing Tertiary strata of the Coastal Plains, we read, "Their water is generally good in the areas of outcrop and for some distance down the dip but is likely to become salty where the formations pass to considerable depths in the direction of the sea."

About 1924, Dr. H. L. Lyon (1925) used the ratio of 1.000 to 1.024 for the densities of normal Honolulu artesian water and sea water, in estimating the reduction of our original supply of fresh underground water. This is in the first part of a typescript, the last part of which was published on Jan. 1, 1925, along with the paper referred to next below.

Carson, McCombs and Rothwell (1925) made a report on the artesian wells of Hono-

lulu, and used Dr. Lyon's density ratio. They estimated that the fall in head to 1925 implied that over 50 per cent of the amount of water originally stored underground had been removed. Though they did not use the term, either they or Dr. Lyon seem to have been the first to hit on the idea of "bottom storage."

A report on the ground waters of the island of Lanai by Palmer (1924) includes a diagrammatic cross section of the water table in an ideal, symmetrical, homogeneous, permeable, and rainy island, showing the upward curve, but it does not have the corresponding downward curve of the base of the fresh water body. Apparently Brown's first paper had been forgotten. Wentworth (1925), in his larger report on Lanai, seems to have been misled by Palmer's erroneous, incomplete cross section.

Another great landmark was Brown's larger paper, published in 1925 though also based on his 1919 field work and subsequent office and library work. It adds little for the present purpose, but it surely had a different and more extensive readership than did the earlier, shorter paper. It has formed the basis for subsequent work on ground waters in Hawaii and many other regions. It includes an annotated bibliography of relevant papers.

One important effect of it may be found published in the abstract of Palmer's paper presented May 19, 1926, before the Hawaiian Academy of Science, namely the use of the "U-tube" analogy for illustrating the balance between salt and fresh water.

A fuller paper resulted from the preceding, and was published in October 1926. So far as appears, it presents the first deductive explanation of the artesian conditions at Honolulu, by the use of three progressively more complex cross sections of ideal, oceanic islands. The first is a symmetrical, homogeneous, permeable, but rainless island, in which sea water fills all the voids below sea level. The second adds an effective amount of rain that eventually supplies fresh water to a lens floating on denser sea water. In discussing this cross section the algebraic derivation of the Herzberg ratio, 40 : 1, is given. The third cross section adds an impermeable coastal capping that thickens the edge of the fresh-water lens so as to cause artesian conditions. Combined in this are the three essential factors: (1) the permeable lava rock aquifer; (2) the impermeable coastal plain cap rock; and (3) the Herzberg principle.

On Sept. 10, 1926, Palmer transmitted to the Honolulu Sewer and Water Commission his report on the Honolulu artesian system (1927). The ideas of the paper discussed just above were included and somewhat expanded. This report made several contributions. One was the explanation of the differences in the heads of the several isopiestic areas as a result of their being partly separated by deep valley fills that acted as inverted, underground dams. Another idea, thought to have been new then, was that of ascribing the gradation downward from fresh through brackish to salt water in the "contact zone" to mixing as a result of rise and fall of the contact zone in response to falling and rising artesian heads. With falling head, the contact zone would rise bringing saltier water where fresher water had been; and with rising head, the contact zone would drop and bring fresher water where saltier water had been.

There was also the first, though inadequate, attempt to study the rate of change in the "transition zone," as we now prefer to call the "contact zone." Studies of the reduction of salinity in two wells by plugging parts of the bottoms, gave changes per foot of plug of 1.75 parts and of 25 parts of chloride per million parts of water. The slow rate of change in the first well was thought to be due to greater fluctuations of the depth to the transition zone as a result of greater fluctuations of the artesian head, with more mixing as a result.

From 1926 on there have been many applications of the Herzberg principle, not only at various places in the Hawaiian Islands, but also on many Pacific islands, especially during World War II. There has also been application

of the principle, with certain necessary modifications, to the stratified sedimentary rocks of the Atlantic and Gulf Coastal Plains, and to the limestones of Florida, as well as to the glacial deposits of Long Island.

In Hawaii, Dr. Chester K. Wentworth, when he was with the Honolulu Board of Water Supply, made important studies of the specific gravity of sea water in connection with the local value of the Herzberg ratio, of bottom storage, of the growth of the transition zone; and of modifications of the Herzberg principle by taking a dynamic instead of the original static view. Mr. L. T. Bryson, Chemist of the Board of Water Supply, has studied, among other things, base exchange in Honolulu ground waters and the nature of the transition zone. Mr. Doak C. Cox, Geologist for the Hawaiian Sugar Planters' Association, has made great progress in studies of the transition zone, of the effects of ocean tides on ground water levels, and of the dynamic *vs.* static view of the Herzberg principle.

I am indebted to Mr. Doak C. Cox, Mr. Leslie J. Watson, and Mr. Erik Palmer for critical reading of the draft of this paper and for their valuable comments.

EPILOGUE

Some years ago we spoke of just the "Herzberg Principle." Then, when it was realized that Badon Ghyben published first, we spoke of the "Ghyben-Herzberg Principle." Next it was learned that the Hollander's family name was double, viz., Badon Ghyben, so it was felt that we should say the "Badon Ghyben-Herzberg Principle." I now propose that we return to the simple form of "Herzberg Principle," with its various parallels, such as "Herzberg Lens." I believe this is justified, although Badon Ghyben published first, because Herzberg (1) had the idea first and used it, and (2) gave a far better presentation of the idea.

REFERENCES

Alexander, William DeWitt. 1908. Theories Concerning Artesian Wells. *Pacific Com. Advertiser*, Oct. 9, 1908, p. 5. Honolulu.

Andrews, Carl Bowers. 1909. "The Structure of the Southeastern Portion of the Island of Oahu." Typescript Master's Thesis, Rose Polytechnic Institute, Terre Haute, Indiana.

Badon-Ghyben, W. with J. Drabbe. 1888–1889. Nota in verband met de voorgenomen put boring nabij Amsterdam. *Inst. Ingén. Tijdschr.*, pp. 8–52. The Hague. (The translation by Kate Kortschak, H.S.P.A. Experiment Station, mimeographed, 1955, was used.)

Brown, John Stafford. 1922. Relation of Sea Water to Ground Water Along Coasts. *Amer. Jour. Sci.*, Ser. 5,4: 274–294.

——— 1925. A Study of Coastal Ground Waters, with Special Reference to Connecticut. *U. S. Geol. Survey*, *Water-Supply Paper* 537.

Carson, Max H., John McCombs, and Guy N. Rothwell. Report of the Artesian Well Committee. *Hawaii Chap.*, *Amer. Assoc. Engin.*, *Bul.* 2, Jan. 1, 1925.

Clapp, Frederick G. 1909. Underground Waters of Southern Maine. *U. S. Geol. Survey*, *Water-Supply Paper* 223.

Gregory, H. E., and E. E. Ellis. 1909. Underground Water Resources of Connecticut. *U. S. Geol. Survey*, *Water-Supply Paper* 232.

Harris, Gilbert D. 1904. Underground Waters of Southern Louisiana. *U. S. Geol. Survey*, *Water-Supply Paper* 101.

Herzberg, Alexander. 1901. Die Wasserversorgung einiger Nordseebäder. *Jour. f. Gasbeleuchtung u. Wasserversorgung* 44: 815–819, and 842–844. Munich. (The translation by Doak C. Cox, H.S.P.A. Experiment Station, mimeographed, 1955, was used.)

Hill, Franklin C. 1875. Water Supply of Islands. *Pop. Sci. Monthly*, pp. 440–444.

Hitchcock, Charles H. 1911. The Geology of Oahu in its Relation to the Artesian Supply. *Hawaii. Forest. and Agr.* 9(1): 27–29.

KEILHACK, KONRAD. 1917. *Lehrbuch der Grundwasser- und Quellenkunde*. 2d ed., rev. and enlarged. Gebrüder Borntraeger, Berlin.

LINDGREN, WALDEMAR. 1903. The Water Resources of Molokai, Hawaiian Islands. *U. S. Geol. Survey, Water-Supply Paper* 77.

LYON, HAROLD L. 1925. Typescript (no title) in H.S.P.A. Library. Part published in *Hawaii Chap., Amer. Assoc. Engin., Bul.* 2, Jan. 1, 1925.

MATSON, G. C., and SAMUEL SANFORD. 1913. Geology and Ground Waters of Florida. *U. S. Geol. Survey, Water-Supply Paper* 319.

MCCULLY, LAWRENCE. 1881. Artesian Wells. *Thrum's Ann., 1882*, pp. 42–46.

MEINZER, OSCAR E. 1923. The Occurrence of Ground Water in the United States. *U. S. Geol. Survey, Water-Supply Paper* 489.

PALMER, HAROLD S. 1919. "Report on the Geology and Ground Water Resources of Peaks Island, Maine." Typescript report to the Public Utilities Commission, Augusta, Maine, Oct., 1919.

——— 1920. Ground Water in the Norwalk, Suffield, and Glastonbury Areas, Connecticut. *U. S. Geol. Survey, Water-Supply Paper* 470.

——— 1921. "Ground Water Resources of Maunalua, Oahu." Typescript report to the Bernice P. Bishop Estate. June, 1921.

——— 1924. "Ground Water Conditions on the Island of Lanai." Typescript report to the Hawaiian Pineapple Co., spring, 1924.

——— 1926*a*. The Form and Structure of the Artesian Areas Underlying Honolulu. (Abstract of paper presented May 19, 1926.) *Hawaii. Acad. Sci., Proc.* Vol. 1. Published as *Bernice P. Bishop Mus., Bul.* 21.

——— 1926*b*. The Honolulu Type of Artesian Structure. *Hawaii. Planter's Rec.* 30(4): 422–433.

——— 1927. "The Geology of the Honolulu Artesian System." Supplement to the report of the Honolulu Sewer and Water Commission, 1927.

PENNINK, J. M. K. 1905. Investigations for Ground-water Supplies. *Amer. Soc. Civ. Engin., Trans.* Vol. LIV, pt. D, pp. 169–181.

SCHUYLER, J. D., and G. F. ALLARDT. 1889. In a report to B. F. Dillingham. From extracts by J. Leslie Watson in a Honolulu Board of Water Supply staff report of 1948, "The Conservation, Development and Protection of the Water Resources of the Honolulu Urban Area."

SPEAR, WALTER E. 1912. Long Island Sources for an Additional Supply of Water for the City of New York. Vol. 1, app. 2, *Location of Proposed Works in Southern Suffolk County*. New York Board of Water Supply.

TAYLOR, THOMAS U. 1907. Underground Waters of the Coastal Plain of Texas. *U. S. Geol. Survey, Water-Supply Paper* 190.

VEATCH, A. C. 1906. Fluctuations of Water Levels in Wells with Especial Reference to Long Island. *U. S. Geol. Survey, Water-Supply Paper* 155.

VEATCH, A. C., C. S. SCHLICHTER, ISAIAH BOWMAN, W. O. CROSBY, and R. E. HORTON. 1906. Underground Water Resources of Long Island, N. Y. *U. S. Geol. Survey, Prof. Paper* 44.

WATSON, J. LESLIE. Personal communication, Jan. 24, 1956.

WENTWORTH, CHESTER K. 1925. The Geology of Lanai. *Bernice P. Bishop Mus., Bul.* 24.

WHITNEY, H. M. 1898. Origin of Artesian Wells in the Hawaiian Islands. *Hawaii. Planter's Monthly* XVII(11): 486–491.

Contributions to the Knowledge of the Alpheid Shrimp of the Pacific Ocean

Part II. Collection from Arno Atoll, Marshall Islands[1]

Albert H. Banner[2]

This paper reports upon a collection of snapping shrimp made by Dr. Robert W. Hiatt and Dr. Donald W. Strasburg, of the University of Hawaii, at Arno Atoll in the southern portion of the Radak chain of the Marshall Islands. Under the sponsorship of the Pacific Science Board with funds from the Office of Naval Research, they visited Arno during the summer of 1950 as a part of a scientific team to investigate the total ecology of the atoll. One additional shrimp reported upon was collected by Dr. J. W. Wells of the same investigation.

This study of the snapping shrimp from Arno was initiated under a grant administered by the U. S. National Museum and the Pacific Science Board under a contract between the Office of Naval Research, Biology Branch, and the National Academy of Sciences, (NR 160–175); some help in the final phases of the study was made available through a grant to the author from the National Science Foundation (NSF-G-1754).

To avoid repititious synonymies and bibliographies in this series of papers, whenever a full citation for a species has been given in an earlier paper, by myself, reference is made to this citation. In this present paper reference is made only to Part I of these studies, describing collections from the Mariana Archipelago (Banner, 1956). Type specimens for the new species described in this paper will be deposited in the United States National Museum.

Arno Atoll

The nature and biology of Arno Atoll has been covered in a series of preliminary reports by members of the investigation team, published (in mimeographed form) in the *Atoll Research Bulletin* (issued by the Pacific Science Board), Numbers 3–11, 1951–1952. A comprehensive book on these studies is now in preparation and specialized scientific reports are appearing in technical journals.

Arno is an irregularly shaped atoll centered about 7° 05′ N., 17° 40′ E. and about 27 miles across its longest axis (Fig. 1). It consists of 133 islands and islets, only a few of which are large enough to support human habitation. The outer margin of the atoll drops off steeply into waters of profound depth; within, the lagoon is estimated to be 100–200 feet deep. The ocean communicates with the lagoon through a series of passes, deep or shallow. The atoll lies in the belt of northeasterly trades and at the southern edge of the North Equatorial Current, which may be replaced during some of the months of northern summer by the Equatorial Countercurrent. The ring of islands is surrounded on both inner and outer margins by coral reefs of varying vitality and breadth, depending upon conditions of wind, surf, sediment, etc.

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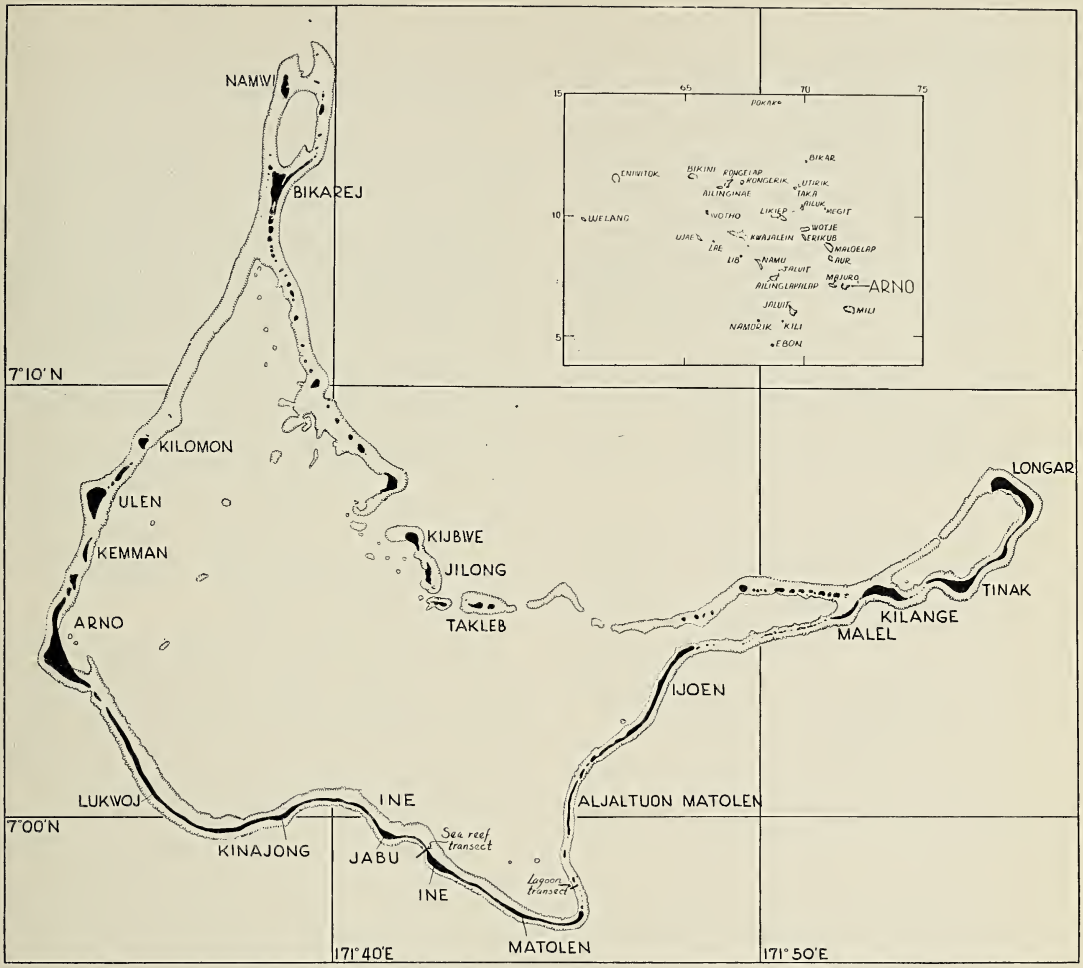

FIG. 1. Map of Arno Atoll, showing collecting stations. *Insert*: A map of the Marshall Islands, showing the location of Arno.

HABITATS OF THE SHRIMP

The studies made by Dr. Hiatt include two ecological sections of the reef in the extreme southern section of the atoll, one on the seaward and one on the lagoon side. The study of the seaward reef was made near the village of Ine, in a region quite protected from the prevailing winds and surf; that of the lagoon reef was made off the islet of Makïn, some 4 miles away.

The method of taking the transects was the same in both cases. A strip 50 feet wide and divided into sections, 50 feet long on the seaward reef and 100 feet long on the lagoon reef, was laid out normal to the shore and running from the beach to water beyond "skin diving" depth. The animals in each section were collected, given field identification and preserved; in the shallow zones this was done by wading, in the deeper by "skin diving."

The contours found on both transects were about the same, showing a broad, relatively flat, gradually sloping reef centering about the height of mean low water. An abrupt change in slope marked the outer margins of the reef flat, with the slope becoming steep on the lagoon reef and precipitous on the ocean side.

A complete report on the ecological study is in preparation by Dr. Hiatt. For this report on a small section of his collections, loaned to me for this study, Dr. Hiatt has permitted me to extract and summarize the following information from his field notes about the zones and specific habitats of the shrimp:

E–1–2. Section XI, seaward reef. Slope beyond edge of reef flat, about 450 feet from shore. Reef face at an angle of about 60°. 82 species of coral collected down to depth of 30 feet, no species being dominant. Alpheids commensal with *Antedon*, a sea lily found clinging to the underside of coral ledges.

E–1–106. Section III, seaward reef. 50–100 feet from beach. Level about that of mean low water (0.0); on low tides area with dry areas and shallow pools. Corals not flourishing, *Montipora gaimardi* the dominant species. Sand and coral fragments in depressions. Alpheids in interstices of *M. gaimardi*.

E–1–122. Section IV, seaward reef. 100–150 feet from beach. In general similar to Section III, about same level. Alpheids as in Section III.

E–1–149. Section V, seaward reef. 150–200 feet from beach. Inner portion alone exposed on extreme low water, outer portions covered by 2–5 inches of water. Level of extreme low water marks division between *M. gaimardi* and *Acropora pectinata* zones. Alpheids as in Section III.

E–1–285, 290. Section VI, seaward reef. 200–250 feet from beach. Water standing at all tides, reef flat bare with no loose sand. Zone with mixed *M. gaimardi* and *A. pectinata*. Alpheids in group 285 collected from living heads of coral and in holes in dead coral, and in group 290 from living heads of *Pocillopora*.

E–1–305. Collected from a brackish pond on Malel Island.

E–1–306. Section VII, seaward reef. 250–300 feet from shore. At tides below 0.3, tips of growing heads of coral exposed. *A. pectinata* dominant coral, covering much of area; *Pocillopora* luxuriant. Alpheids from dead bases and living branches of coral; some from living heads of *Pocillopora*.

E–1–387, 388. Section VIII, seaward reef. 300–350 feet from shore. Highest parts of corals exposed only on extreme low waters. *A. pectinata* dominant with *Pocillopora* secondary; a brown alcyonarian, *Lobularia krempfi*, also occurring in numbers. Alpheids collected from heads of *Acropora* and *Pocillopora*.

E–1–611, 630, 643, 648. Section IX, seaward reef. 350–400 feet from shore. Section similar to Section VIII, the depth slightly greater and area commonly flooded with foam from surf much of day. *A. pectinata* and *Pocillopora* still dominant corals. Alpheids collected from heads of *Acropora* (617,643), *Pocillopora* (619, 630), and *Stylophora* (648).

E–1–670. Section II, seaward reef. From edge of water at mean high tide to a point 80 feet seaward. Exposed beachrock pitted and covered with fine, short algae; area marked by large tide pools varying from 4 to 8 inches deep. Alpheids collected from tide pool.

E–2–169, 311. Section II, lagoon reef. From mean high tide level to 100 feet towards the lagoon. Outer margin uncovers at 0.0 tide. Covered with quite smooth beachrock, with a few shallow tide pools; outer portions covered by a fine sand veneer. No corals present. Alpheids collected under loose slabs of beachrock (169) and in holes in the rock (311).

E–2–343, 382. Section IV, lagoon reef. From 200–300 feet from shore, depth from 4 to approximately 60 feet. Area with bottom covered with sand and coral rubble, and numerous species of coral with those of the genus *Acropora* dominant. Alpheids collected from heads of *Seriatopora hystrix* (343) and *Stylophora* (382).

E–2–360. Section III, lagoon reef. From 100–200 feet from shore. Depth from 0.0 to 4 feet. Section of bottom covered with fine sand and coral rubble; luxuriant growth of corals with species of *Acropora* dominant. Alpheids collected from *Stylophora mordax*.

ATHANAS Leach

Athanas djiboutensis Coutière, 1897

For synonymy, see Banner, 1956.

LOCALITIES: One specimen each at E–1–290 and E–1–388.

DISCUSSION: The two specimens cannot be assigned positively to this species for they are both fragmentary, lacking their chela and some other appendages. However, the appendages still remaining, and especially the form of the rostrum and the orbital spines about the eyes, compare almost perfectly with the specimens from Saipan identified as this species.

Athanas marshallensis Chace
Fig. 2

Athanas marshallensis Chace, U. S. Natl. Mus., Proc. 105(3349): 17, fig. 8, 1955.

LOCALITIES: One non-ovigerous female from E–1–122.

DISCUSSION: This specimen differs in only one way from the description and figure of Chace: in this specimen the extracorneal spines reach almost to the anterior margin of the eyes, instead of midway along the eyes as in Chace's specimens. It is likely, however, that the eyes are rotated backwards towards the body, for the "collar" of the anterior carapace that usually fits snugly about the eyes is loose and stands out from the corneas in this specimen.

METABETAEUS Borradaile

Metabetaeus minutus (Whitelegge)

Betaeus minutus Whitelegge, Austral. Mus., Mem. 3: 147, pl. 7, fig. 4, 1897.

Metabetaeus minutus Borradaile, Zool. Soc. London, Proc. 66: 1014, 1898.

Metabetaeus minutus Coutière, Soc. Ent. de France, Bul. 1899(19): 374, 1899a.

LOCALITIES: Four specimens, all females without eggs, maximum length 17 mm., E–1–305.

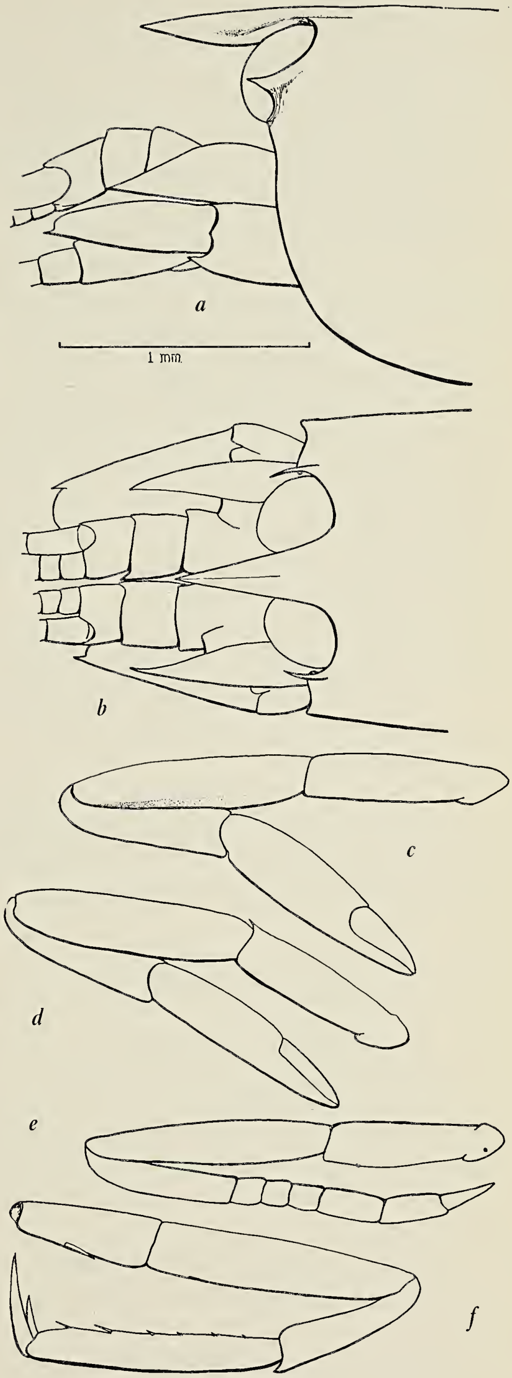

FIG. 2. *Athanas marshallensis* Chace. *a, b,* Anterior body region; *c,* right cheliped; *d,* left cheliped; *e,* second leg; *f,* third leg. (All same scale.)

DISCUSSION: These specimens agree almost perfectly with Whitelegge's original description and with the later redescriptions. The only differences found are in the anterior body region when compared to the plate of the original description. In these specimens the rostrum is almost an equilateral triangle with straight sides and slightly rounded tip, while Whitelegge showed and described his specimen as having a slightly more narrow rostrum with concave sides and an acute tip. Further, the concavity between the base of the rostrum and the orbital spines is more pronounced. Finally a difference is found on the relative lengths of the antennular and antennal peduncles, for in these specimens the antennular peduncle is slightly longer than the antennal, rather than the reverse as described by Whitelegge. These differences are minor and most likely of no importance.

Otherwise the specimens agree in the general form, the proportions of the appendages, the branchial formula and even in the possession of a brown spot on *corpus mandibulae* described by Coutière.

The type specimens came from a mangrove swamp, and, previous to this report, were the only specimens known. The ones described from Arno came from a brackish pond.

SYNALPHEUS Spence Bate

Comatularum Group

Synalpheus carinatus (de Man)

Alpheus carinatus de Man, Arch. f. Naturgesch., 53: 508, pl. 22, fig. 2, 1887.

Synalpheus carinatus de Man, Siboga Exped. 39a[1](2): 210, pl. 5, fig. 23, 1911.

nec Synalpheus carinatus Pearson, Report on Pearl Oyster Fisheries, p. 83, pl. 2, fig. 9, 1905.

LOCALITIES: One specimen at E–1–2, (commensal with *Antedon*, a sea lily).

DISCUSSION: This specimen agrees perfectly with the characteristics given by de Man. The ova are 1.1 by 0.7 mm. The species will be discussed more fully in a later paper. Hiatt notes that the color in life was brownish-black, the same as the host, *Antedon*.

Synalpheus consobrinus de Man

Synalpheus consobrinus de Man, Nederland. Dierk. Ver., Tijdschr. II, 11: 111, 1909.

Synalpheus consobrinus de Man, Siboga Exped., 39a[1](2): 204, pl. 6, fig. 21, 1911.

LOCALITIES: One specimen at E–1–643.

Neomeris Group

Synalpheus charon charon (Heller)
Fig. 3

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens each at E–1–617 and E–1–630.

DISCUSSION: These four specimens are of the parent subspecies with the expanded base to the superior unguis of the third to fifth legs, and with a rostrum of uniform taper.

One specimen from E–1–617, however, had a greatly expanded palm of the large chela with greatly reduced fingers. The condition is slightly more pronounced than that found in *S. macromanus* Edmondson (1925: 9), and at first the specimen was tentatively identified as that species. But *S. macromanus* has a conical inferior unguis on the third leg and is otherwise similar to *S. paraneomeris* Coutière, while this specimen is identical to *S. charon* except for the form of the large and small chelae.

The question is how this enlargement of the chela should be interpreted. When there was but the one specimen known as *S. macromanus* it was logical to consider the modification to be of specific worth; if this specimen were similar to *S. macromanus*, that species would have been considered as more valid. However, with specimens related to two different species showing a parallel mutation, I believe that the condition could best be interpreted as a growth anomaly that may occur in several species of this genus. The fact that this spec-

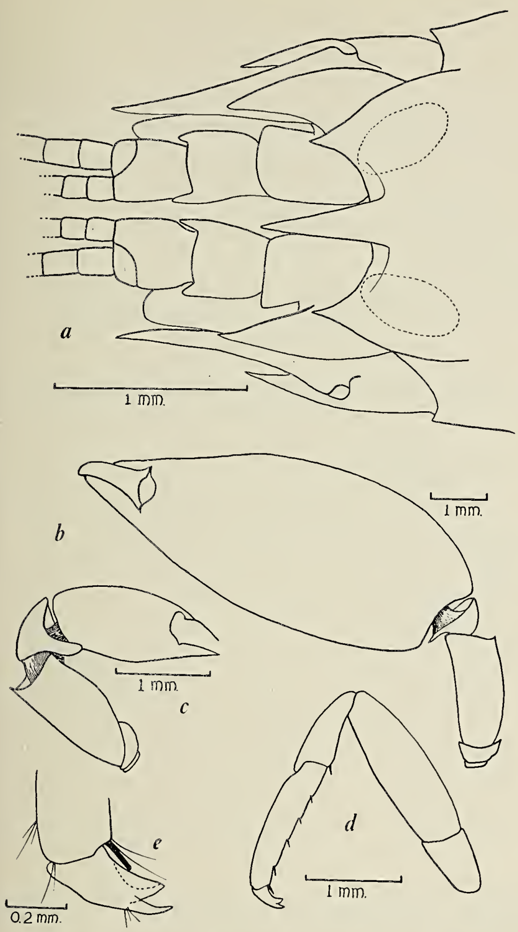

FIG. 3. *Synalpheus charon charon* Banner, aberrant form. *a*, Anterior body region; *b*, inflated large chela and cheliped; *c*, small cheliped of normal form; *d*, third leg; *e*, third leg, dactylus.

imen was one of a sole pair, male and female, the other being plainly *S. charon charon*, collected at one locality would offer support to this conclusion.

If this be so, then the original *S. macromanus* must be considered to be an aberrant form of *S. paraneomeris* Coutière.

Synalpheus paraneomeris Coutière

For synonymy, see Banner, 1956.

LOCALITIES: One specimen at E–1–106, 3 at E–1–306.

Coutierei Group

Synalpheus coutierei Banner
Fig. 4

Synalpheus coutierei Banner, Pacific Sci. 7(1): 36, 1953.

Synalpheus biunguiculatus Coutière, Soc. Ent. de France, Bul. 1898(11): 232, figs. 1–4, 1898 [and other authors—see Banner *op. cit.*].

nec Alpheus biunguiculatus Stimpson, Acad. Nat. Sci. Phila., Proc. 1860: 31.

LOCALITY: Three specimens at E–2–382.

DISCUSSION: These specimens are plainly of this species as illustrated by Coutière (*loc. cit.* and 1905: 873, pl. 31, fig. 8). However, they show slight differences in the proportions of the various parts of taxonomic significance, most apparently in the antennular peduncle, wherein the second article is relatively longer, in the small cheliped, in the dactylus of the third leg, and in the telson. These variations are shown in Figure 4.

Coutière (1898) has shown some variations in the anterior regions and in the dactyli of specimens collected in various parts of the Indian Ocean which approach the differences noted here; he also (1905: figs. 8, 10) described and depicted the form found in the Maldive and Laccadives, and described as a separate variety a form whose variations markedly exceed those of this group of specimens. I believe that considering the variations already reported and the variations in related species of *Synalpheus*, no taxonomic importance should be attached to the slight differences found in these specimens from Arno.

Synalpheus lophodactylus Coutière

Synalpheus lophodactylus Coutière, Soc. Philomath. Paris, Bul. IX, 11(5): 7, 1908.

Synalpheus lophodactylus Coutière, Linn. Soc. London, Trans., Zool. II 17(4): 421, pl. 61, fig. 11, 1921. [Text the same as 1908 reference, plates not previously published.]

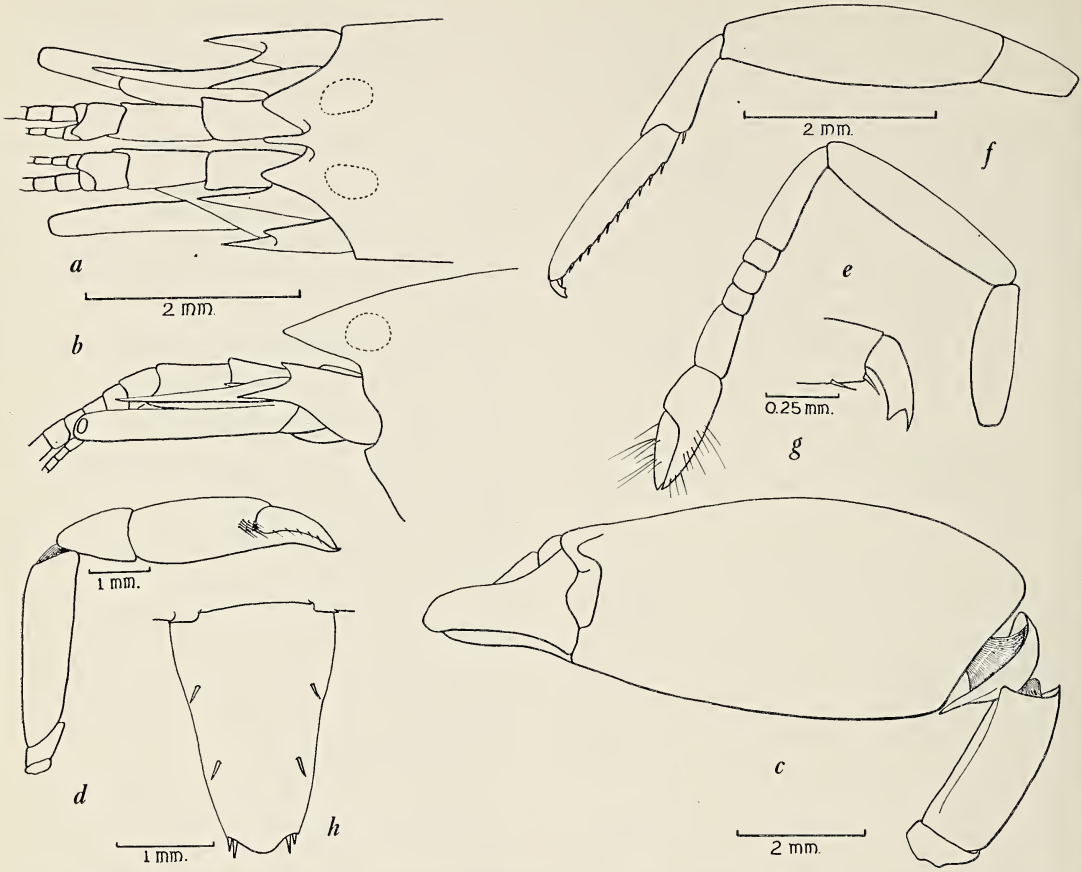

FIG. 4. *Synalpheus coutierei* Banner. *a*, *b*, Anterior body region; *c*, large cheliped; *d*, small cheliped; *e*, second leg; *f*, third leg; *g*, third leg, dactylus; *h*, telson.

LOCALITY: One female, collected at station E–2–343.

DISCUSSION: This specimen agrees well with Coutière's description and figures of his type, the sole specimen reported until now, except for several minor details. The setae on the small chela, shown as a definite tuft and described as "une brosse de soies sériées . . . moins sériées et moins abondantes que dans le groupe *laevimanus* . . .", appear to be less abundant in the distal tuft in this specimen and are also found proximal to the tuft in a row leading towards the articulation. The inferior distal margin of the merus of the third leg bear a feeble movable spine, instead of being unarmed as depicted by Coutière. Finally, the posterior lateral angles of the telson are produced into slender acute teeth almost as long as the lateral distal spines instead of being broader and relatively shorter as shown by Coutière. However, the proportions of the small chela and third legs are almost exactly the same as in the type.

The specimen described by Coutière lacked the large chela, which is intact but slightly distorted in this specimen. It is of typical form for the genus, with the fingers occupying the distal 0.3 of the chela, and the height being about 0.4 of the total length (this proportion may not be accurate because of the condition of the appendage). The merus is 0.5 as long as the chela and 2.5 times as long as broad. The merus and the dactylar articulation are unarmed.

ALPHEUS Fabricius

Megacheles Group

Alpheus deuteropus Hilgendorf, 1878

For synonymy, see Banner, 1956.

LOCALITY: One specimen at E–1–387.

Alpheus collumianus probabalis Banner, 1956

For synonymy of these subspecies and the parent species, see Banner, 1956.

LOCALITY: One specimen from the coral reef at Ine, collected by Wells.

DISCUSSION: The single specimen of this subspecies is markedly more hairy than were the specimens from Saipan; the long setae are especially noticeable on the antennular peduncle, the chelae, and the third and following legs. Moreover, the meri of the third and fourth legs bear 5–6 spines, instead of 4 as in the type, while the merus of the large chela has only 2 small weak spines instead of 6 strong spines that were carried by the type.

Alpheus collumianus medius Banner, 1956

LOCALITIES: Two specimens at E–1–387, 1 at E–1–617.

Macrochirus Group

Alpheus gracilis var. **simplex** Banner, 1953

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E–1–306, both defective; 1 at E–1–387.

DISCUSSION: This single intact specimen is almost identical to the specimens from Hawaii except that it bears a trace of a rostral carina, a condition also noted in one of the aberrant specimens from Hawaii. The external spine of the uropod is black.

The two other specimens are assigned to this species with question for they are lacking their chelae and some of the other appendages. The parts remaining, as well as the structure of the anterior carapace, agree very well with the specimens from Hawaii.

Alpheus ventrosus Milne-Edwards, 1837

For earlier synonymy, see Banner, 1956.

Alpheus sp. Coutière, in Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 882, pl. 74, fig. 19, 1905.

Crangon latipes Banner, Pacific Sci. 7(1): 82, fig. 27, 1953.

LOCALITIES: Four specimens at E–1–290; 3 at E–1–306; 2 at E–1–387; 3 at E–1–617; 5 at E–1–630; 1 at E–2–343.

DISCUSSION: Specimens from station E–1–630 and E–1–290 present an incomplete intergradation from the form described as *C. latipes* and the mature *A. ventrosus*. The intergradation indicated by these specimens is confirmed by specimens from other areas and will be discussed more fully in a subsequent paper. One specimen in this collection shows the darkened spine on the uropods (as discussed in the specimens from Saipan).

Alpheus amirantei Coutière

Alpheus amirantei Coutière, Soc. Philomath. Paris, Bul. IX, 11(5): 15, 1908.

Alpheus amirantei Coutière, Linn. Soc. London, Trans., Zool. II, 17(4): 421, pl. 63, fig. 16, 1921. [Text the same as 1908 reference.]

LOCALITY: One specimen at E–1–611.

DISCUSSION: This specimen appears to be somewhat intermediate in many characters between the type that Coutière described for the Indian Ocean and the Hawaiian form. The relative lengths of the antennular peduncle, antennal peduncle and scaphocerite are subequal, like Coutière's specimen, instead of having the scaphocerite markedly the longest. The basicerite bears a relatively strong spine, like the Hawaiian specimen. This specimen, a female, has slightly longer fingers to the large chela than does the Hawaiian form. The second carpal article of the second leg is 2.7

times the length of the first, instead of 2.3 in the Hawaiian form, and 3.0 in Coutière's. The inferior distal tooth of the merus of the third leg is longer and more acute than in the Hawaiian form, therefore more like the type specimen. Finally, the Arno specimen is unlike both previous forms in the armature of the merus of the large and small chela. In Coutière's specimen the inferior internal margin of the merus carried a series of rounded serrations terminating in a strong acute tooth; in the Hawaiian specimens the serrations were lacking, and the tooth was weaker; in the Arno specimen the tooth also is lacking. The merus of the small chela was armed with a tooth in the type but in both the Hawaiian and Arno specimens the tooth is lacking.

However, as the specimen agrees well with the general description of *A. amirantei*, these differences are considered to be at most subspecific, and are more likely to be individual variation.

Alpheus nanus (Banner) 1953

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E–1–306.

DISCUSSION: Like the specimens from Saipan, the sole specimen with the chelae intact, a male, had spinules on the inferior internal margin of the merus; both large and small chelae had seven such spinules. The other specimen, a female, was lacking in both chelae.

Alpheus paragracilis Coutière, 1897

For synonymy, see Banner, 1956.

LOCALITIES: One specimen at E–1–106; 2 at E–1–285; 3 at E–1–387; 2 at E–1–617.

Alpheus macrochirus Richters

Alpheus macrochirus Richters, Meeresfauna der Insel Mauritius und der Seychellen, Decapoda, p. 164, pl. 17, figs. 31–33, 1880.

nec Alpheus macrochirus de Man, Arch. f. Naturgesch. 53(1): 519, 1887.

LOCALITIES: Two specimens at E–1–306; 2 at E–2–360.

DISCUSSION: These specimens agree well with the short original description, with the characteristics given in de Man's key and discussion (1911) and with the three figures in Coutière's *Les Alpheidae* (1899, figs. 51, 52, 261).

Crinitus Group

Obesomanus Subgroup

Alpheus lutini Coutière, 1905

For synonymy, see Banner, 1956.

LOCALITIES: Three specimens at E–1–106; 12 at E–1–122; 30 at E–1–149; 5 at E–1–285; 5 at E–1–290; 16 at E–1–306; 5 at E–1–387; 5 at E–1–611; 1 at E–2–343; 1 at E–2–382.

DISCUSSION: One specimen preserved in formaldehyde has a body colored pale lemon yellow, intensifying to bright lemon yellow on the legs. The anterior region of the carapace and the antennular and antennal bases are orange-red; the small and especially the large chelae are lemon yellow at the proximal ends, changing to almost blood red at the tips. Some other specimens show a similar color pattern except that the red of the tips of the chelae is restricted to irregular patches surrounded by white. It is not known how well this pigmentation parallels that found in the living specimens.

Crinitus Subgroup

Alpheus alcyone de Man

Alpheus alcyone de Man, Senckenb. Naturf. Gesell. Abhandl. 25: 870, pl. 27, fig. 61, 1902.

Alpheus aculeipes Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 892, pl. 79, fig. 31, 1905.

Alpheus alcyone de Man, Siboga Exped. 39a[1] (2): 351.

LOCALITIES: One specimen at E–1–285; 1 at E–1–611; 1 at E–1–617; 1 at E–1–648; 5 at E–2–382.

Alpheus arnoa sp. nov.

Fig. 5

TYPE SPECIMEN: A non-ovigerous female, 12.2 mm. long, collected on Arno Atoll, Marshall Islands, by R. W. Hiatt at station E–2–343. Only specimen known.

DESCRIPTION: Frontal region of carapace extending considerably beyond eyes. Rostrum short, triangular, reaching about 0.5 the length of visible portion of first antennular article; dorsally bearing a strong and abrupt carina that extends to slightly posterior of gastric region. Orbital hoods rounded, somewhat inflated, anteromedially extending into flattened area, at highest about equal in height to dorsal carina, laterally demarked by an abrupt groove from carapace which covers base of antennal peduncle. Orbitocarinal groove shallow and rounded; orbitorostral area flattened.

Second antennular article slightly less than twice as long as broad, 1.5 times as long as visible portion of first article, 1.7 times as long as third article; diameter only 0.6 that of the first article. Stylocerite acute, with tip reaching almost to end of first article. Basicerite unarmed. Scaphocerite with lateral margin strongly concave, spine heavy, somewhat blunt, reaching beyond end of antennular peduncle; squamous portion narrow and shorter, reaching to middle of third antennular article. Carpocerite reaching to end of scaphocerite.

Large chela subcylindrical, slightly tapering, entire, 2.8 times as long as broad, with the fingers occupying the distal 0.3. Dactylus arched and rounded, calcified and white distally. Tip of fixed finger similarly calcified. Merus 0.37 as long as chela, with outer face 1.8 times as long as broad; all margins unarmed, but inferior internal margin projecting into a low but strong extension. Chela with only sparse scattered setae. Small chela 3.5 times as long as broad, with simple conical fingers occupying the distal 0.38. Carpus somewhat elongate. Merus slightly longer (about 10%) than that of large cheliped, 2.5 times as long as broad, also unarmed. Chela bearing a moderate growth of setae on superior distal face.

Carpus of second legs with the ratio: 10:21:8:7:11.

Ischium of third legs bearing strong tooth. Merus 4 times as long as broad, armed with a strong acute tooth distally. Carpus unarmed except for poorly developed distal inferior tooth, 0.3 as long as merus. Propodus 3.5 times as long as broad, 0.66 as long as merus, armed on inferior margin with five strong spines and five weaker spines. Propodus and dactylus with usual scattered sparse setae. Dactylus curved, simple, and well developed. Fourth legs of similar armature and proportions.

Telson 2.4 times as long as posterior margin is broad, anteriorly 1.4 times as broad as posteriorly, sides with slight taper; anterior pair of dorsal spines 0.39, posterior pair 0.60 of length posterior from articulation; distal lateral spines moderately strong; strongly arcuate distal margins armed with numerous short heavy spines. Outer uropod with strong lateral spine and with distal margin armed with numerous shorter spines in addition to usual setae. Inner uropod bearing eight strong spines on distolateral margin and numerous short heavy spines similar to those of the telson along distal margin.

DISCUSSION: This species belongs to the Crinitus subgroup, and within the subgroup it appears to be most closely related to those other species with an extended dorsal carina, *A. bucephaloides* Nobili, *A. longecarinatus* Hilgendorf, and *A. parvus* de Man. From the first two species it can most easily be distinguished by the lack of spines on the carpus of the third legs. *A. parvus* lacks the armature of the carpus, like this species, but the configuration of the anterior margin of the cara-

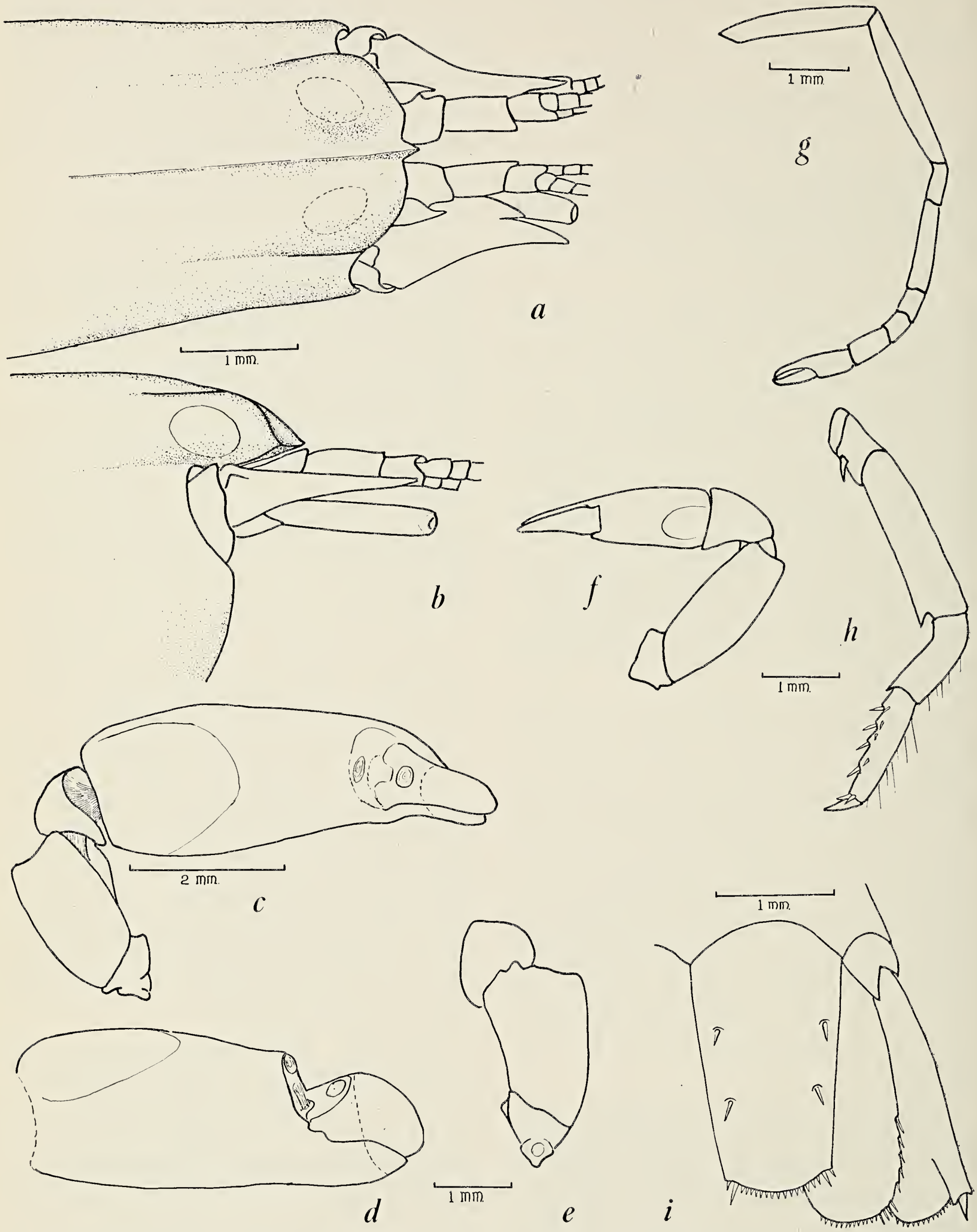

FIG. 5. *Alpheus arnoa* sp. nov. *a*, *b*, Anterior body region; *c*, large cheliped, lateral aspect; *d*, large chela, inferior aspect; *e*, large cheliped, merus, medial aspect; *f*, small cheliped; *g*, second leg; *h*, third leg; *i*, telson and uropods.

pace is different, (compare Fig. 5*a* to de Man, 1911, pl. 15, fig. 74), the flattened portion of the scaphocerite is longer and more narrow, the second carpal article is only 1.3 instead of 2.1 times as long as the first, the telson is more tapering and the spines and spinules of the uropods and telson were unreported by de Man.

The specific name refers to the type locality.

Alpheus bucephalus Coutière

Alpheus bucephalus Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2(4): 890, pl. 78, fig. 29, 1905.

Alpheus consobrinus de Man, Leyden Rijks Mus. van Naturlijke Hist. Zool. Meded., Notes 30:101, 1908.

Alpheus consobrinus de Man, Siboga Exped. 39a[1]: 360, pl. 16, fig. 75, 1911.

LOCALITIES: One specimen at E–1–122; 11 at E–1–306; 4 at E–2–360.

DISCUSSION: *A. consobrinus* was recognized by de Man as being closely related to *A. bucephalus* and *A. clypeatus* Coutière, but was separated by him on the basis of the following characteristics:

1. The scaphocerite is slightly longer than the carpocerite in *A. consobrinus* and slightly shorter in *A. bucephalus.*

2. The basicerite is armed with a minute tooth in *A. consobrinus* and unarmed in *A. bucephalus.*

3. The merus of the large chela bears an acute tooth on the inferior internal margin in *A. consobrinus* while in *A. bucephalus* the corresponding projection is rounded.

4. The small chela is usually dimorphic in *A. consobrinus*, the males bearing an expanded dactylus with a fringe of setae, while in *A. bucephalus* the dactylus of the small chela of the male is narrow, conical and without a fringe of setae, a condition similar to that of the females.

5. The second article of the second leg is three times the length of the first in the males of *A. consobrinus* while in both sexes of *A. bucephalus* (according to de Man's key) it is "more than twice as long as the first." (However, Coutière's figure 29c shows it to be about 2.75 times as long as the first.)

6. The telson is slightly more narrow in *A. consobrinus*, the length-breadth ratio being 2.6, while in *A. bucephalus* where the ratio is 2.2.

This impressive list of differences would lead one to believe that the species are separate and distinct. However as previously reported from Saipan, the broadening of the dactylus of the males is not a constant characteristic. In this series of specimens a group collected at E–1–306 shows that each one of these characteristics is individually variable. In Table 1 a tabulation of these characteristics of 10 intact specimens is given. The relative lengths of the scaphocerite and carpocerite are quite variable; the spine of the basicerite is present in only two specimens; the meral spine of the large chela varies from strong and acute to low and rounded; the dimorphic character of the small chela of the males does not seem to be correlated with size or other characteristics; the ratio of the first two secondary articles of the second leg varies from 1.7, a figure below that of *A. bucephalus*, to 3.5, a figure above that of *A. consobrinus;* and, finally, the telsal length-breadth ratio ranges from 2.1 to 2.9, the last in the smallest specimen. Moreover, the variations are not correlated with each other, so a specimen like *A. consobrinus* in the sexually dimorphic chela does not have the tooth on the basicerite, etc.

These variations parallel or exceed the variations previously reported upon for the closely related *A. clypeatus* Coutière and *A. brevipes* Stimpson (Banner, 1953: 103–110). I believe that when sufficient specimens are examined from all parts of the range of these four nominal species, it is very likely that the species will all be found to be part of a single, very variable species. However, the present series of specimens do not offer enough direct evidence to warrant this lumping except to combine *A. consobrinus* with *A. bucephalus.*

TABLE 1

VARIATION IN ONE SAMPLE OF *Alpheus bucephalus* COUTIÈRE

Sex	Length, mm.	Length of scaphocerite compared to carpocerite	Tooth on basicerite	Tooth on merus of large cheliped	Length of second carpal article ÷ length of first	Telson, length ÷ breadth at base	SMALL CHELA OF MALES: Length Palm, mm.	Length Dactyl, mm.	Length Palm ÷ length, Dactylus	Breadth Dactylus at base, mm.	Length Dactylus ÷ breadth	Breadth Dactylus 0.3 distance from base, mm.	Ratio, breadths of Dactylus	Setae	Sexual Dimorphism
♀*	13.4	equal	abs	strong, acute	1.7	2.2									
♀*	11.2	scaphocerite longer	pres	strong, acute	2.3	broken									
♀*	10.3	equal	abs	low, obtuse	2.7	2.3									
♀	6.5	equal	abs	lacking	1.8	2.8	A	B	A/B	C	B/C	D	C/D	. .	. .
♂	9.3	scaphocerite longer	abs	low, rounded	1.9	2.1		(lacking)					(lacking)		
♂	8.7	carpocerite longer	abs	strong, obtuse	2.5	2.4	1.07	1.04	1.0	0.40	2.7	0.40	1.0	fringe	yes
♂	8.5	carpocerite longer	abs	strong, acute	3.5	2.6	1.15	0.95	1.3	0.29	3.3	0.22	1.4	scattered	no
♂	8.1	scaphocerite longer	abs	strong, acute	2.8	2.5	1.00	1.00	1.0	0.37	2.9	0.37	1.0	fringe	yes
♂	8.1	carpocerite longer	pres	strong, acute	2.9	2.1	1.18	1.33	0.9	0.51	2.6	0.55	0.9	fringe	yes
♂	7.6	carpocerite longer	abs	low, rounded	2.2	2.9	1.00	0.62	1.7	0.29	2.1	0.15	1.9	scattered	no

* Ovigerous females

Alpheus clypeatus Coutière

Alpheus clypeatus Coutière, Fauna and Geog. Maldive and Laccadive Archipelagoes 2 (4): 897, pls. 81–82, fig. 36, 1905.

LOCALITIES: Three specimens at E–1–306 (fragmentary and uncertain); 4 at E–1–617; 5 at E–1–648; 4 at E–2–343.

Alpheus pachychirus Stimpson, 1860

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E–1–290.

Alpheus frontalis H. Milne-Edwards, 1837

For synonymy, see Banner, 1956.

LOCALITY: Two specimens at E–1–611.

Diadema Subgroup

Alpheus bidens (Olivier)

Palaemon bidens Olivier, Encyclopédie Méthodique, Histoire Naturelle 8: 663, 1811.
Alpheus bidens H. Milne-Edwards, Histoire Naturelle des Crustacés 2: 353, pl. 24, figs. 11, 12, 1837.
Alpheus tridentatus Zehntner, Rev. Suisse de Zool. 2: 204, pl. 8, fig. 24, 1894.

LOCALITIES: Two specimens at E–2–360; 1 at E–2–382.

DISCUSSION: These specimens show considerable variation from each other despite the fact that there are only three specimens involved. On one specimen the dorsal denticles of the anterior carapace reach almost to the base of the eyes, while the other two are considerably shorter (but not placed as far posteriorly as indicated by de Man, 1911: pl. 17, fig. 80). The rostrum on one does not reach quite to the end of the first antennular article, on the second reaches slightly beyond it, and on the third reaches almost to the middle of the second article. The first antennular article bears one movable spine and two long setae in two of the specimens, but in the third carries one spine on one side and two spines (as shown by de Man) on the opposite article. On the merus of the large chela the armature varies, with one specimen bearing feeble spines on the inferior internal margin, only several exceedingly weak spines on superior margin, while the inferior external margin carried only about 10 poorly developed serrations; on the second specimens the spines of the inferior internal are quite strong, the superior margin carries 7 short but strong spines, and the serrations on inferior external margin are marked; the third specimen is intermediate between these two.

However in other characteristics, these specimens compare sufficiently well to the descriptions of the species that these variations cannot permit one to consider them as other than this species.

Alpheus diadema Dana, 1852

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E–1–149; 1 at E–1–290; 2 at E–2–343; 2 at E–2–360.

Alpheus percyi Coutière

Alpheus percyi Coutière, Soc. Philomath. Paris, Bul. 9(5): 21, 1908.
Alpheus percyi Coutière, Linn. Soc. London, Trans., Zool. II, 17(4): 426, pl. 64, fig. 22, 1921. [Same description, figures added.]

LOCALITY: Two specimens at E–2–382.

DISCUSSION: This specimen agrees very well with the specimens from the Hawaiian archipelago except for the rostrum. In the Hawaiian species the rostrum bears a low, obtuse but definite crest, but in these two specimens the rostrum is dorsally flat and smooth. While Coutière does not discuss this characteristic in his original description, his figures in his 1921 publication (figs. 22, 22^1) seem to indicate a condition similar to these Marshall specimens. It may be that the Hawaiian specimens will be found to represent a geograph-

ically isolated subspecies, but not enough specimens are known to draw any conclusions as yet.

Alpheus gracilipes Stimpson, 1860

For synonymy, see Banner, 1956.

LOCALITIES: Two specimens at E–1–306; 2 at E–1–387; 3 at E–1–617.

DISCUSSION: Of these 7 specimens, 2 males and 2 females had their small chelae intact; all 4 had the characteristic fringe of hair over the dactylus, but none had their fingers noticeably broadened. These specimens, therefore, are like the form found in Hawaii and not like the form from the Marianas.

Alpheus paracrinitus var. **bengalensis** Coutière, 1905

For synonymy, see Banner, 1956.

LOCALITY: One specimen at E–1–106.

Edwardsi Group

Alpheus crassimanus Heller

Alpheus crassimanus Heller, Reise der . . . Novara . . . Zool. Theil 2(8): 107, pl. 10, fig. 2, 1865.

LOCALITIES: One specimen at E–1–387; 2 (fragmentary) at E–1–670; 3 at E–2–311.

DISCUSSION: The fragmentary specimens were assigned to this species because those parts remaining were almost identical to specimens of similar size from Hawaii.

One specimen was somewhat unlike the rest with the sculpturing on the large chela deeper and more abrupt, and the second and third legs thinner and more elongate (the merus of the third legs is 6 times as long as broad instead of the reported 4.5 to 5.0 times). However similar variation in the large chela has been reported for Hawaiian specimens (Banner, 1953: 134), and for this comparison, the meri of a group of specimens collected from a single area in Kaneohe Bay, Oahu, Hawaii, were measured, and it was found that the length-breadth ratio varied from 4.5 to 6.0.

Alpheus strenuus Dana

Alpheus strenuus Dana, U. S. Explor. Exped. 13(1): 543, pl. 34, fig. 4, 1852.

LOCALITIES: One specimen at E–2–169; 6 specimens, Arno, records lost.

DISCUSSION: Some of these specimens, the largest I have yet seen, reach a total body length of 57 mm.; Coutière (1905: 913) has reported specimens reaching 95 mm., but his figures included the chelae.

The distinction between this species and *A. audouini* described by Coutière in 1905 appears to be somewhat questionable. Coutière makes the distinction upon the form of the anterior carapace and rostrum, and the form of the large chela, but the distinctions are so fine as to be scarcely apparent in his figures. Considering the variations that have been reported for other species of the genus, these fine distinctions appear to be of dubious validity. Probably the best differentiations may be found in the antennular base, where the median article is 1.5 times the length of the distal article in *A. audouini* and 2 times the length in *A. strenuus;* in the second legs, where the first article is 1.65 times the length of the second in *A. audouini* and 1.0 to 1.2 times the length in *A. strenuus;* and in the merus of the third legs where the length is 4.3 times the breadth in *A. audouini* and 3.7 times the breadth in *A. strenuus*. Even these differences could easily be within the normal range of variation for an inherently variable species.

Alpheus pacificus Dana, 1852

For synonymy, see Banner, 1956.

LOCALITY: Three specimens at E–1–106.

Alpheus dolerus Banner

Alpheus dolerus Banner, Pacific Sci. 10 (3): 362, fig. 2.

LOCALITIES: One specimen each at E-1-617 and E-2-343.

DISCUSSION: While these specimens compare well to the types and paratypes from Saipan, positive identification is impossible because both are females, and males are necessary for identification in this group.

Alpheus parvirostris Dana, 1852

For synonymy, see Banner, 1956.

LOCALITIES: Three specimens at E-1-106; 11 at E-1-122; 9 at E-1-149; 1 at E-1-285; 1 at E-1-290; 6 at E-1-306; 1 at E-1-387; 1 at E-1-611.

REFERENCES

BANNER, ALBERT H. 1953. The Crangonidae, or snapping shrimps, of Hawaii. *Pacific Sci.* 7(1): 1–147, figs. 1–50.

——— 1956. Contributions to the knowledge of the Alpheid shrimp of the Pacific, I. Collections from the Mariana Archipelago. *Pacific Sci.* 10(3): 318–373, figs. 1–23.

BORRADAILE, L. A. 1898. On some crustaceans from the South Pacific. Part III. Macrura. *Zool. Soc. London, Proc.* 1898: 1000–1015, pls. 63–65.

CHACE, FENNER A., JR. 1955. Notes on shrimps from the Marshall Islands. *U. S. Natl. Mus., Proc.* 105(3349): 1–17, 8 figs.

COUTIÈRE, HENRI. 1898. Note sur Synalpheus biunguiculatus Stimpson ? de Man [Crust.]. *Soc. Ent. de France, Bul.* 1898(11): 232–233, figs. 1–4.

——— 1899*a*. Sur le genre Metabetaeus Borradaile. *Soc. Ent. de France, Bul.* (19): 374–377.

——— 1899*b*. Les "Alpheidae," morphologie externe et interne, formes larvaires, bionomie. Thèses présentées à la Faculté des Sciences de Paris . . . Sér. A, No. 321 [No. d'Ordre 980]. 599 pp., 409 text figs., 6 pls. Masson et Cie., Paris. [Also in: *Ann. Sci. Nat.* VIII, Zool. 9: 1–560.]

——— 1905. Marine Crustacea, XV. Les Alpheidae. In: *Fauna and Geography of the Maldive and Laccadive Archipelagoes.* [J. Stanley Gardiner, ed.] Vol. 2, pt. 4, pp. 852–921, pls. 70–87, figs. 127–139. University Press, Cambridge.

——— 1908. Sur quelques nouvelles espèces d'Alpheidae. *Soc. Philomath. Paris, Bul.* IX, 11(5): 191–216 (1–25).

——— 1921. Les espèces d'Alpheidae raportées de l'Océan Indien par M. J. Stanley Gardiner. *Linn. Soc. London, Trans.* II, (Zool.) 17(4): 413–428, pls. 60–64. [Also titled: *Reports of the Percy Sladen Trust Expedition to the Indian Ocean* in 1905 . . . 6(10): 413–428 etc.]

DANA, JAMES D. 1852. Crustacea. In: *United States Exploring Expedition, During the Years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, U.S.N.* Vol. 13, viii + 685. [Folio Atlas of 96 plates published in 1855.]

DE MAN, JOHANNES GOVERTUS. 1887. Bericht uber die im Indischen Archipel von Dr. J. Brock gesammelten Decapoden und Stomatopoden. *Arch. f. Naturgesch.*, vol. 53, pt. 1, pp. 215–600, pls. 7–22a.

——— 1902. Die von Herrn Professor Kukenthal im Indischen Archipel gesammelten Dekapoden und Stomatopoden. *Senckenb. Naturf. Gesell. Abhandl.* 25: 467–929, pls. 19–27.

——— 1908. Diagnoses of new species of Macrurous Decapod Crustacea from the "Siboga-Expedition." III. *Leyden Rijks Mus. van Natuurlijke Hist. Zool. Meded., Notes* 30(14): 98–112.

——— 1909. Diagnoses of new species of Macrurous Decapod Crustacea from the "Siboga-Expedition." IV. *Nederland. Dierk. Ver., Tijdschr.* 11(2): 99–125.

——— 1911. The Decapoda of the Siboga Expedition. Part II. Family Alpheidae. In: *Siboga Expeditie* 39a[1](2): 133–465 [Livre 60];

1915, supplement [plates and explanations] 39a¹(2): 23 pls. [Livre 74].

EDMONDSON, CHARLES HOWARD. 1925. Crustacea. Marine Zoology of the Tropical Central Pacific. *Bernice P. Bishop Mus., Bul.* 27: 3–22, figs. 1–3.

HELLER, CAMIL. 1865. Crustaceen.[Abth. 8]. In: *Reise der Osterreichischen Fregatte Novara um die Erde in den Jahren 1857–58–59 unter den Befehlen des Commodores B. von Wüllerstorf-Urbair*. Zool. Theil, Band II, no. 8, 280 pp., 25 taf.

HIATT, ROBERT W. 1951. Marine Zoology Study [sic] of Arno Atoll, Marshall Islands, *Atoll Research Bul.* 4: ii + 13. [Mimeographed.]

MILNE-EDWARDS, HENRI. 1837. *Histoire naturelle des Crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux.* Tome II. 532 pp. Roret, Paris.

OLIVIER, A. G. 1811. Palémon. Palaemon. In: Olivier, A. G., *Encyclopedie Methodique, Histore Naturelle* 8: 652–667.

PEARSON, JOSEPH. 1905. Report on the Macrura collected by Professor Herdman, at Ceylon, in 1902. In: *Report to the government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar* by W. A. Herdman, 4(24): 65–92, pls. 1, 2.

RICHTERS, F. 1880. Crustacea Decapoda of Mauritius and the Seychelles. In: *Beiträge zur meeresfauna der insel Mauritius und der Seychellen* . . . [K. Möbius, ed.] vi + 352 pp., 25 pls. Gutmann, Berlin.

STIMPSON, W. 1861. Prodomus descriptionis animalium evertebratorum, quae in expeditione ad Oceanum Pacificum Septentrionalem . . . Pars. VIII. Crustacea Macrura. *Acad. Nat. Sci. Phila., Proc.* 12: 22–47. [Proc. for 1860.]

WHITELEGGE, T. 1897. The Crustacea of Funafuti. The Atoll of Funafuti, Ellice Group: its Zoology, Botany, Ethnology, and General Structure based on Collections made by Mr. Charles Hedley, of the Australia Museum, Sydney, N. S. W. *Austral. Mus., Mem.* 3: 125–151, pls. 6, 7.

ZEHNTNER, L. 1894. Crustacés de l'Archipel Malais. Voyage de M. Bedot et C. Pictet dans l'Archipel Malais. *Rev. Suisse de Zool.* 2: 135–214, pls. 7–9.

Systematic Anatomy of *Hesperomannia*

SHERWIN CARLQUIST[1]

THE GENUS *Hesperomannia* (Compositae, tribe Mutisieae) has attracted interest because of its arborescent habit, its restriction to certain of the Hawaiian Islands, and its rarity in the locations in which it is found. The purpose of the present paper is to survey the anatomical diversity which exists in the genus and relate it to gross morphological characters in an attempt to achieve an acceptable classification. The affinities of *Hesperomannia*, as suggested particularly in terms of anatomical characters, are to be discussed in later studies. Within the genus, however, anatomical features seem illuminating in demonstrating the most natural taxonomic groupings.

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MATERIALS AND METHODS

Vegetative material of the writer's collection of *H. arborescens* subsp. *Swezeyi* was fixed in a Carnoy's solution (3 parts absolute ethyl alcohol: 1 part glacial acetic acid). All other material was prepared from herbarium specimens as follows. Vegetative and floral parts were treated with warm 2.5 per cent aqueous NaOH to remove cell contents and expand structures to their original condition. Further clearing was achieved by treatment with a 250 per cent chloral hydrate solution. After washing, whole mount preparations of flowers and leaves were made by dehydration in an ethyl alcohol series, staining in a 1 per cent safranin solution in absolute ethyl alcohol, transferring to xylene, and mounting in xylene-soluble synthetic resin. Portions of both the Carnoy's-fixed material and the "revived" herbarium material were prepared for sectioning according to the tertiary butyl alcohol schedule of Johansen (1940: 130–131). Treatment with hydrofluoric acid prior to infiltration was necessary for softening woody structures. Sections were stained with a safranin-fast green combination corresponding to Northen's modification of Foster's tannic acid-ferric chloride method (Johansen 1940: 92–93). All of the collections for which anatomical data were assembled are represented in the Bernice P. Bishop Museum in Honolulu, except where otherwise noted. Duplicates of many of these specimens are in other herbaria.

ANATOMY

The Leaf

Examination of young leaves near the shoot apex of *Hesperomannia arborescens* subsp. *Swezeyi* showed them to be densely covered with uniseriate nonglandular hairs (Fig. 1). Interspersed among these are biseriate glandular trichomes. At such an early stage, virtually every epidermal cell on both surfaces

[1] Rancho Santa Ana Botanic Garden, Claremont, California. Manuscript received February 9, 1956.

FIG. 1. Longitudinal section of young petiole of *Hesperomannia arborescens* subsp. *Swezeyi* (*Carlquist H3*), × 170. Short biseriate glandular hairs may be seen near the epidermis (below), interspersed among crowded uniseriate nonglandular hairs, which cover most of the photograph.

of the leaf bears a trichome of one of these types. This condition is true of all of the species. A preparation of the most glabrous species, *H. Lydgatei*, showed an identical situation. During enlargement of the young leaf of *H. arborescens* subsp. *Swezeyi*, there is a tendency for the uniseriate trichomes to degenerate and slough off. In Figure 1, the uniseriate trichomes already show an accumulation of dark-staining resinous contents, indicating the beginning of their decline relatively soon after formation. Upon maturation of the leaf of this plant (Fig. 2), uniseriate hairs have disappeared altogether, except for occasional persistent basal cells. Simultaneously, the biseriate glandular trichomes increase in size and become sunken into pockets as the mesophyll expands.

Differences in leaf indument, which are treated here as important characters of the species, may be explained on the basis of differential elimination of trichomes during maturation of the leaf. In *H. arbuscula* subsp. *oahuensis*, for example, uniseriate hairs are retained, particularly on the young stems and lower surfaces of leaves (Fig. 3). In this species, uniseriate hairs, particularly the terminal cell of each, become sclerified, corresponding with their persistence. Biseriate glandular hairs are also present on the mature leaf of *H. arbuscula* subsp. *oahuensis*. Although less numerous, both types of trichomes may also be found on mature leaves of *H. arbuscula* subsp. *arbuscula*. *Hesperomannia arbuscula* is the only species in which uniseriate trichomes are retained on the mature leaf.

In *H. Lydgatei*, *H. arborescens* subsp. *arborescens*, subsp. *Bushiana*, and some populations of subsp. *Swezeyi* (*Judd 1244*, for example), both types of trichomes disappear early in leaf ontogeny. In leaves of these taxa, a heavy cuticle is formed on both adaxial and abaxial epidermis.

Variations in leaf thickness occur in all the species, and cannot be considered as a constant taxonomic character.

Peduncle

Among the taxa recognized here under *H. arbuscula* and *H. arborescens*, little variation in

FIG. 2. Transection of a mature leaf of *Hesperomannia arborescens* subsp. *Swezeyi* (*Carlquist H3*), × 130. Abaxial epidermis at left. Note vein, accompanied by sclerenchyma, remnants of uniseriate hairs on the abaxial surface, and sunken glandular hairs.

FIG. 3. Lower surface of mature leaf of *Hesperomannia arbuscula* subsp. *oahuensis* (*Hillebrand 1871*), × 140. Numerous sclerified hairs may be seen above the vein reticulum.

peduncle size or structure occurs. A peduncle of *H. arborescens* subsp. *Bushiana*, shown in Figure 4A, is typical in its numerous bundles and sclereid nests. Trichomes are persistent on the epidermis of peduncles in these two species. *Hesperomannia Lydgatei*, on the contrary, shows peduncles much smaller in diameter. This smaller stature is reflected anatomically in the fewer bundles present in the vascular cylinder and in the much smaller size of the pith (Fig. 4B). In addition, no hairs are present on the peduncle epidermis of *H. Lydgatei*, which is covered by a prominent cuticle.

Involucral Bracts

As in peduncle anatomy, the involucral bracts of plants belonging to *H. arbuscula* and *H. arborescens* are comparatively uniform in anatomical structure. As shown for *H. arborescens* subsp. *Swezeyi* in Figure 4C, a thick region of subhypodermal fibers occurs near the outer face of the bract in these species. Epidermal and hypodermal cells on this surface remain thin-walled. This zone of fibers may be as many as 14 cells in thickness. On the interior face of the bract, a thinner band of fibers is present. The adaxial epidermis is most heavily sclerified, with decreasing wall thickness on the two or three cell layers interior to it. Between the fibers on the inner and outer faces of the bract, a region of thin-walled parenchyma is present. A single series of vascular bundles occurs in this region. The thickness of this central parenchyma band is greatest near the base of the bract and decreases toward the apex.

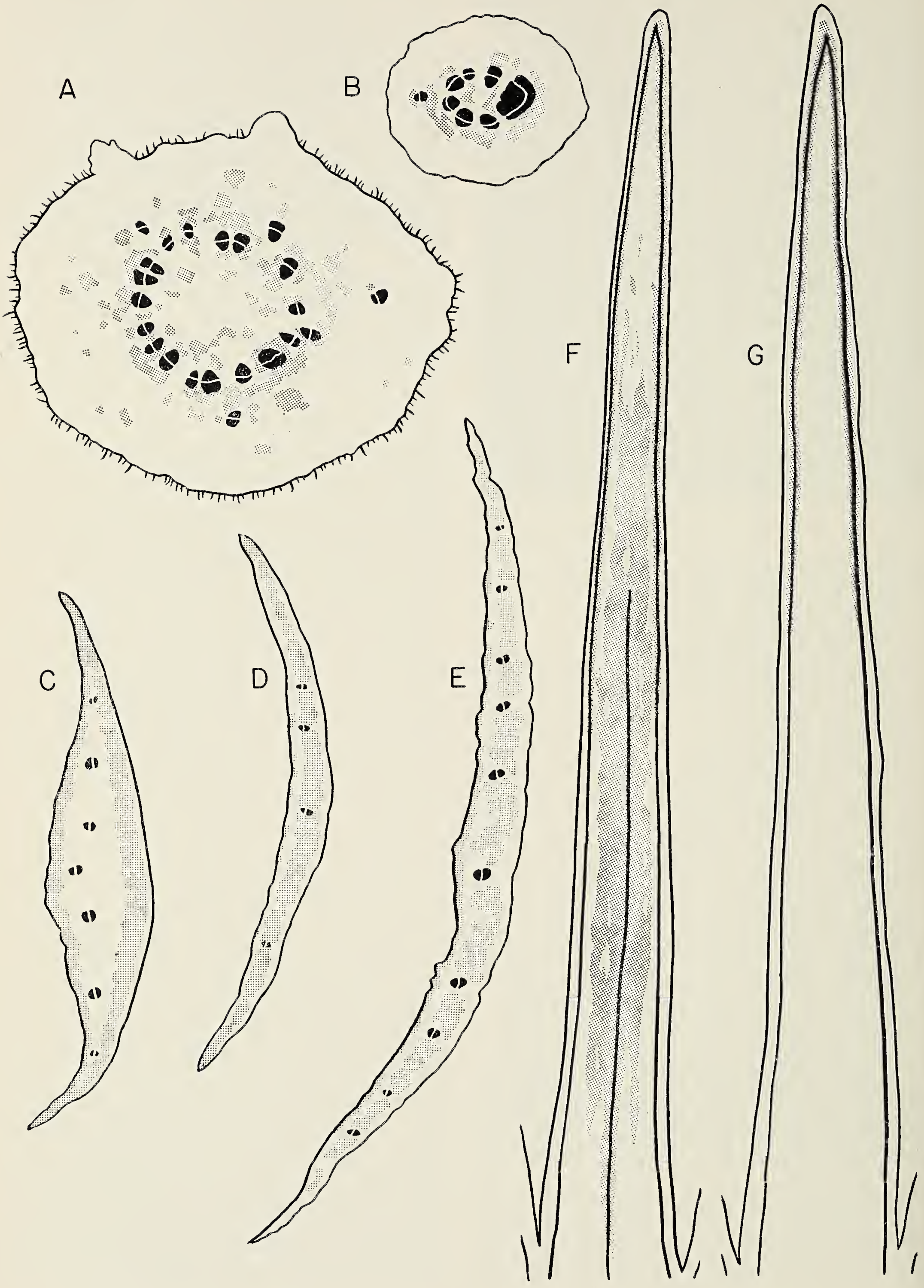
Inner involucral bracts show an altered form of this structure in the two species, as the bract of *H. arborescens* subsp. *Bushiana* in Figure 4D demonstrates. In such a bract, the region of parenchyma between the two bands of fibers is greatly narrowed. The bundles occur at points within the outer band of fibers, rather than in the parenchyma. The outer band of fibers is continuous, or nearly so, and encases most of the bundles.

The involucral bracts of *H. Lydgatei* show a structure comparable only to the inner involucral bracts of the other species. Bundles occur only in interstices between the strands of fibers, which never form a continuous band as they do in the bract of *H. arborescens* subsp. *Bushiana* described above.

Corolla

As is typical for Compositae, a pair of lateral veins, which fuse beneath each sinus, is present in each corolla lobe in *Hesperomannia* flowers. In addition, median veins, such as shown in Figure 4F, were found to be present in both subspecies of *H. arbuscula* as well as in *H. arborescens* subsp. *Swezeyi*. Such median veins are present in one to three of the larger corolla lobes of a flower in these taxa, or are absent in some flowers. Where present, they extend for varied distances in the lower portion of the lobe. No median veins were found in the taxa not mentioned.

Fibers encase the upper extent of the lateral veins of corolla lobes (Fig. 4F, G) in all


A
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G

species. In addition, subepidermal cells interior to the lateral veins of the lobe may become sclerified; such diffuse sclereids were found in all the subspecies of *H. arborescens* and *H. arbuscula*. The extent of these sclereids is shown diagrammatically in Figure 4F for *H. arborescens* subsp. *Swezeyi*, in which they were abundant. They were least abundant in *H. arbuscula* subsp. *arbuscula*, and altogether lacking in *H. Lydgatei* (Fig. 4G). Sclereids of this type appear in the young flowers, and increase in size until the corolla withers. As shown in Figure 5, these sclereids become impacted against each other, forming blunted ends and distorted shapes. Because of the presence of such sclereids, median veins in corolla lobes can be detected with certainty only in cleared preparations. Although sclereids of this nature have never been reported in the Compositae before, they have been found by the writer in a number of Mutisieae.

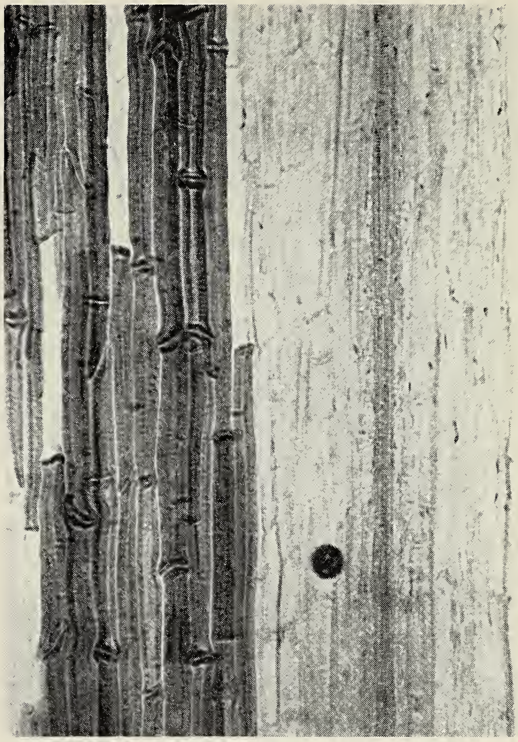

FIG. 5. Portion of cleared corolla-lobe of *Hesperomannia arborescens* subsp. *Swezeyi* (*Judd 1244*), × 175. Margin of lobe at right; inward from the margin may be seen the lateral vein, a glandular hair (out of focus), and a number of subepidermal sclereids, left.

EVOLUTION WITHIN THE GENUS

Characters of gross morphology alone give few suggestions concerning presumed evolutionary advancement within *Hesperomannia*. One feature which deserves mention is the tendency toward aggregation of heads. In most Mutisieae, particularly putatively primitive genera, the heads are solitary and terminal. In *Hesperomannia*, they may be solitary, but are more frequently in clusters of 2 to 10. Where fewer peduncles are present, they are borne coordinately at the end of an axis. Where more numerous peduncles form a cluster, some peduncles may branch from others. If more than one head is present, no leaves or bracts subtend the additional heads. In view of the fact that clusters of heads are present in all of the taxa except *H. arborescens* subsp. *Bushiana*, which would appear to be derived on other grounds, such clusters may have been primitively present in *Hesperomannia*, despite the solitary condition elsewhere in the Mutisieae.

Anatomical characters seem to offer more reliable criteria of primitiveness, though few features can be cited in this regard. The caducous hairs on herbage and peduncles may be interpreted in this connection. One would expect the development of mature trichomes to be more primitive than the condition where they are lost at an early stage. In this case, *H. arbuscula* shows the most primitive expression of this character. *Hesperomannia Lydgatei* shows the most advanced condition,

←FIG. 4. A, B, transections of peduncle near base, × 30. A, *Hesperomannia arborescens* subsp. *Bushiana* (*Degener 11927a*); B, *H. Lydgatei* (*Forbes 190K*). C–E, transections of involucral bracts, midway along length of bract, × 21. C, *H. arborescens* subsp. *Swezeyi* (*Judd 1244*), outer bract; D, *H. arborescens* subsp. *Bushiana* (*Degener 11927a*), inner bract; E, *H. Lydgatei* (*Forbes 190K*), outer bract. F, G, corolla lobes, × 15. F. *H. arborescens* subsp. *Swezeyi* (*Judd 1244*); G, *H. Lydgatei* (*Forbes 190K*). Outlines and veins shown in black, sclerenchyma shaded.

since it lacks trichomes on both mature leaves and peduncles. *Hesperomannia arborescens* shows intermediate stages, since uniseriate hairs are present on peduncles, though lacking on mature leaves. Biseriate glandular trichomes have likewise disappeared from mature leaves in some populations of this species.

The involucral bracts of *H. Lydgatei* may be interpreted as advanced in their structure. Likewise, the lack of median veins in corolla lobes of this species, despite optimal lobe-width, would seem to be an advanced characteristic. Absence of median veins in flowers of *H. arborescens* subsp. *arborescens* and subsp. *Bushiana* may similarly be interpreted as reductions, if the generally-accepted tenet of Koch (1930: 940) that median veins are primitively present in the family is correct.

Thus, *H. arbuscula* would seem to possess the more primitive characteristics. *Hesperomannia arborescens* shows somewhat more advanced features, while *H. Lydgatei* is differentiated from the other species by characters which seem best interpreted as the most advanced condition in the genus.

SYSTEMATIC TREATMENT AND DISCUSSION

The writer has had the privilege of studying type or isotype material of all of the species of *Hesperomannia*. In addition, the collections of the three largest assemblages of specimens of this genus, those of the Bishop Museum, the Gray and Arnold herbaria at Harvard, and the Herbarium of the University of California, Berkeley, have been examined. This comparatively large amount of material has permitted a more comprehensive picture of species variability than has previously been available. The descriptions of Degener (1946) are adequate for indicating some of the extremes of variation, particularly in the complex recognized here as *H. arborescens*. These descriptions do not incorporate the intermediate expressions of characters that are found in many specimens, however, and the discussions following each of the taxa below emend these descriptions where necessary, suggesting the most constant characters for each taxon recognized.

KEY TO SPECIES AND SUBSPECIES

1A. Peduncles 1.8 mm. in diameter or less, glabrous; inner involucral bracts 3.5 to 5 cm. long; corolla lobes without diffuse sclereids . . . . **H. Lydgatei**

1B. Peduncles 3 mm. in diameter or more, bearing hairs even at maturity; inner involucral bracts 3.3 cm. long or less; corolla lobes with diffuse sclereids in subepidermal layers 2

2A. Leaves elliptic, the lamina base acute; abaxial surface of mature leaf covered with numerous uniseriate sclerified hairs . . . . 3. **(H. arbuscula)**

3A. Straggling shrub; hairs on abaxial surface of leaf relatively sparse; diffuse sclereids in corolla lobes infrequent; West Maui . . . . **H. arbuscula** subsp. **arbuscula**

3B. Tree; abaxial surface of leaf densely coated with hairs; numerous diffuse sclereids present in corolla lobes; Waianae Mts., Oahu . . . . **H. arbuscula** subsp. **oahuensis**

2B. Leaves lanceolate to oblanceolate or obovate, the lamina base acuminate; no uniseriate hairs present on mature leaves . . . . 4. **(H. arborescens)**

4A. Achenes at maturity 12–14 mm. long; no median corolla veins present; Lanai . . **H. arborescens** subsp. **arborescens**

4B. Achenes at maturity 12 mm. or less in length; median corolla veins present or not; Koolau Mts., Oahu 5

5A. Heads solitary or in clusters of 2 to 10; heads containing 30 or more flowers; median veins present in some corolla lobes . . **H. arborescens** subsp. **Swezeyi**

5B. Heads solitary, containing approximately 25 flowers; no median veins in corolla lobes . **H. arborescens** subsp. **Bushiana**

1. **Hesperomannia Lydgatei** Forbes

Hesperomannia Lydgatei Forbes, Bernice P. Bishop Mus., Occas. Paper 4: 220, 1909.

This species is the most distinct in the genus, by virtue of its geographic isolation (endemic to Kauai) and numerous morphological and anatomical features. As shown above, the peduncles are glabrous and markedly narrower than those of the other species. The long, lanceolate involucral bracts are distinctive both in size and shape and in their anatomy. The lack of diffuse sclereids in corolla lobes has been mentioned earlier. In features of vegetative anatomy, however, no differences can be found between *H. Lydgatei* and the other species. The leaves and stems were found to be identical in shape and anatomy to some plants referred here to *H. arborescens* subsp. *Swezeyi* (*Judd 1244*, for example). Consequently, the difference in these respects suggested by Forbes (1909: 220) cannot be maintained. Although it has not been collected since 1910, this species may still be extant.

Representative specimens—Kauai, Wahiawa Mts.: *Lydgate, May 1908* (type, BISH[2]), *Forbes 190K* (A, BISH, UC).

2. **Hesperomannia arbuscula** Hillebrand

Hesperomannia arbuscula Hillebr., Fl. Hawaii. Is., 232, 1888.

Compared with *H. Lydgatei*, the remaining taxa are remarkably uniform. *Hesperomannia arbuscula* has been maintained as distinct here because of its geographical distribution and the constancy of the leaf shape and indument characters. In addition, the occurrence of slightly different plants on Oahu and West Maui respectively suggests that if the two populations are to be recognized as separate subspecifically, they are best grouped as a species separate from *H. arborescens*.

[2] Abbreviations of herbaria according to J. Lanjouw and F. A. Stafleu, Index Herbariorum, Part I, 1954, Utrecht.

2A. **Hesperomannia arbuscula** subsp. **arbuscula**

This taxon is known only from the type collection. Since repeated exploration of West Maui has failed to rediscover this plant, it may be extinct. Because the type at Berlin is apparently destroyed and the sterile type fragment at the Bishop Museum is inadequate, the isotype material in the Gray Herbarium remains the only usable material.

Representative specimens — West Maui: *Bishop, 1871* (type fragment, BISH; isotype, GH).

2B. ***Hesperomannia arbuscula*** subsp. ***oahuensis*** (Hillebr.) comb. nov.

Hesperomannia arborescens var. *oahuensis* Hillebr., Fl. Hawaii. Is., 232, 1888.

Hesperomannia oahuensis (Hillebr.) Degener, Flora Hawaiiensis. 1938.

Hesperomannia oahuensis, like the earlier variety of Hillebrand, was erected on the basis of material from Mt. Kaala, Oahu. Since Degener copied the description of *H. arbuscula* from that of Hillebrand, did not illustrate *H. arbuscula*, and cited the type only as "before 1888," it seems likely that Degener did not study the fertile specimens of *H. arbuscula* (mentioned above) extant at that time. Examination of both Oahu and Maui material reveals the small differences noted in the key above, but close identity in all other characters. Contrary to Degener's description of *H. oahuensis*, leaves with dentate margins may be found in this taxon.

Representative specimens—Oahu, Mt. Kaala and vicinity: *Hillebrand, 1871* (GH), *Degener and Salucop 11200* (BISH, GH).

3. **Hesperomannia arborescens** Gray

Hesperomannia arborescens Gray, Amer. Acad. Arts and Sci., Proc. 6: 554, 1886.

The type specimen of *H. arborescens* was collected on Lanai. Subsequent to Gray's description of this species, the first in the genus,

various authors have found difficulty in separating specimens collected later on Oahu from the Lanai material. Rock (1913: 507) and Skottsberg (1944: 512) find considerable similarity. Examination of the type specimens of all the taxa treated here as *H. arborescens*, as well as the numerous specimens which have been collected at various stations in the Koolau Mts., Oahu, reveals that considerable variability exists in this species. The descriptions of Degener for taxa in this group do not allow for this variability, as the comments below will indicate. The characters used by Degener in separating the species of this group have been found to have frequent exceptions and various degrees of intermediacy. For this reason the writer has found it inadvisable to maintain the species proposed by Degener.

3A. **Hesperomannia arborescens** subsp. **arborescens**

The Lanai population of *H. arborescens* has not been encountered since a single tree was seen in 1931, and may now be assumed to be extinct. It is only dubiously separable from Oahu material. As the type specimen and the collection *Munro 492* show, clusters of fewer heads, pubescent involucral bracts, and glandular trichomes on the achenes, thought by Degener to be characteristic only of Oahu plants, may be found in the Lanai material. The latter is maintained as a subspecies here because of its geographical isolation and seemingly slightly longer achenes, although it is possible that longer achenes may be found in future collections of mature Oahu material. The leaves do not match those of a particular Oahu population in that they combine a broad shape with a prominently toothed margin and are glabrous. These leaf characters, however, may all be found in Oahu plants.

Representative specimens—Lanai, near summit: *Mann and Brigham 357* (type and isotype, GH), *Hillebrand, 1874* (GH), *Munro 492* (A, BISH).

3B. ***Hesperomannia arborescens*** subsp. ***Bushiana*** (Degener) comb. nov.

Hesperomannia Bushiana Degener, Flora Hawaiiensis. 1933.

The small population found at the crest of Halawa ridge, Koolau Range, Oahu, is the most distinctive in the *H. arborescens* complex. The type specimen and the collection *Degener 11927a* show that the heads are uniformly solitary and smaller than in subsp. *Swezeyi*. The smaller head size, however, is not so pronounced as Degener's description indicates. Heads with as few as 30 flowers may be found in specimens of subsp. *Swezeyi* such as *Degener 10007; H. Bushiana* was described by Degener as having "approximately 25 flowers" per head. Solitary heads are occasional or frequent in populations treated here as subsp. *Swezeyi*. The combination of narrow leaves with toothed margins is not represented in other populations, but equally narrow leaves and leaves with toothed margins may be found independently in various localities, so the combination of these two characters in subsp. *Bushiana* is not surprising. In view of the closeness of this plant to some populations of subsp. *Swezeyi*, it has seemed preferable to recognize it as a subspecies in this complex, rather than a species coordinate with *H. arborescens*.

Representative specimens—Oahu, Koolau Range, Halawa: *Bush et al. 9981* (type, BISH), *Degener 11927a* (BISH).

3C. ***Hesperomannia arborescens*** subsp. ***Swezeyi*** (Degener) comb. nov.

Hesperomannia Swezeyi Degener, Flora Hawaiiensis. 1933.
Hesperomannia Bushiana var. *Fosbergii* Degener, Flora Hawaiiensis. 1937.

Within this subspecies are included all the populations of the Koolau Range except *H. arborescens* subsp. *Bushiana*. This group has been previously divided by Degener into *H. Swezeyi* and *H. Bushiana* var. *Fosbergii*. He

regards the latter as intermediate between *H. Swezeyi* and *H. Bushiana*. While this variety could be interpreted as being intermediate in number of heads per cluster, it has entire leaves, which are not characteristically found in either *H. Bushiana* or the plants regarded by Degener as *H. Swezeyi*. The type of *H. Swezeyi* is based upon material from the northern end of the Koolau Range. Other similar plants may be found midway along this range, in Kipapa and Halawa canyons, for example, as well as at the east end, on Mt. Konahuanui. While the type of *H. Bushiana* var. *Fosbergii* comes from the middle portion of the range (Kalauao ridge), plants which would have to be referred to this variety by virtue of limited numbers of heads and entire leaves may also be found at the north end of the range (e.g., *Fosberg 9419*), separated from the Kalauao populations by what could only be interpreted as *H. arborescens* subsp. *Swezeyi*. Thus, *H. Bushiana* var. *Fosbergii* has no geographical unity. Moreover, a number of specimens show intermediacy, as indicated below. It seems best to refer all the Koolau Mts. material except the extreme variant treated here as *H. arborescens* subsp. *Bushiana* to *H. arborescens* subsp. *Swezeyi*. *Hesperomannia arborescens* would seem to be an instance in which a species is broken up by the severe topography found in the Hawaiian Islands into small colonies in which various characters attain degrees of stabilization independently. Taxonomic recognition of portions of such a polymorphic complex does not seem advisable in most instances, since the essential continuity of the variation pattern is then lost.

Representative specimens—Oahu, Koolau Range. Specimens typical of "*H. Swezeyi*": Pupukea-Kahuku trail: *Degener and Swezey 4398* (type, BISH), *Degener and Shear 3397* (GH); Anahulu trail: *Degener et al. 10079* (BISH); S. Opaeula ridge: *Suehiro, Sept. 1933* (BISH); Kipapa trail: *Hosaka 619* (BISH), *Fosberg 9820* (BISH), *Degener et al. 10007* (BISH); Halawa trail: *Degener 11927* (BISH), *Carlquist H3* (BISH, UC); Mt. Konahuanui: *Rock 1910* (A), *Rock 1912* (GH). Specimens typical of "*H. Bushiana* var. *Fosbergii*": Laie-Waimea trail: *Fosberg et al. 9419* (BISH); Waimalu-Hanaiki trail: *Judd 1244* (BISH); Waimalu-Kalauao trail: *Fosberg 9470* (type, BISH). Specimens showing intermediacy between the above two types: Waimea ridge: *Forbes 2035.0* (BISH); Pupukea-Kahuku trail: *Degener 7445* (BISH), *Degener 7448* (BISH); Wahiawa gulches: *Forbes 1703.0* (BISH, UC).

REFERENCES

DEGENER, OTTO. 1946. *Flora Hawaiiensis* (as a unit; parts published variously). Privately printed.

FORBES, CHARLES N. 1909. Some new Hawaiian plants. *Bernice P. Bishop Mus., Occas. Paper* 4: 213–223.

JOHANSEN, DONALD A. 1940. *Plant Microtechnique*. xi + 523 pp. McGraw Hill, New York.

KOCH, MINNA F. 1930. Studies in the anatomy and morphology of the composite flower. I. The corolla. *Amer. Jour. Bot.* 17: 938–952.

ROCK, JOSEPH F. 1913. *The Indigenous Trees of the Hawaiian Islands*. 518 pp. Privately printed. Honolulu.

SKOTTSBERG, CARL. 1944. Vascular plants from the Hawaiian Islands. IV. *Göteborgs Bot. Trädg., Meddel.* 15: 275–531.

The Life History of the Polychaetous Annelid *Neanthes caudata* (delle Chiaje), Including a Summary of Development in the Family Nereidae[1]

DONALD J. REISH[2]

THE STUDY OF REPRODUCTION, development, and life history of the polychaete family Nereidae has attracted considerable attention in the past. Stimulus for this interest undoubtably is due, in part, to the world-wide distribution of the family, the phenomenon of epitoky (=heteronereis), and the diverse reproductive patterns. A total of 20 species of nereids has been studied in the past; information about them has been summarized in Table 1. Reproduction and development of *Neanthes caudata* have been studied previously by Herpin (1923, 1924, 1926) at Cherbourg, France. He reared this species through the 24-segmented stage.

This is the first report of the species in the Pacific Ocean. Fauvel (1923) stated that it inhabited muddy and sandy bottoms in Europe, and recently Day (1953) reported it from South Africa. The first specimens from the Pacific were encountered in a suspended sediment bottle collector (adapted from Thorson, 1946) which had been exposed for a 28 day interval in the West Basin of Los Angeles Harbor in November–December 1953. Quantitative bottom surveys of Los Angeles—Long Beach Harbors were made during August 1951 (Anon., 1952), and again in January 1954, but *N. caudata* was not taken. However, *N. caudata* was taken at many stations in both harbors in the surveys made in June and November 1954. It is believed to have been recently introduced into the harbor, possibly by ships.

MATERIALS AND METHODS

Culture Techniques

Living specimens were collected from sediment bottle collectors suspended for 28 days in the West Basin of Los Angeles Harbor. The techniques employed for culturing adults are in general similar to those utilized by the author for the adults of *Nereis grubei* (Kinberg) (Reish, 1953; 1954). Best results were obtained when the worms were placed in separate petri dishes. The worms were fed *Enteromorpha* sp., usually twice a week. This green alga was collected in quantities from estuaries in southern California. This alga was dried, and, prior to using, a small amount was soaked in sea water for a few minutes. Mud and sand, that had previously been dried, were substituted for *Enteromorpha* sp. with some success, but the use of the alga was

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favored because of the greater ease in observing the animal. The water in the petri dishes was changed at irregular intervals, usually once every two or three weeks.

Since the male incubates the fertilized eggs and larvae (Herpin, 1926), the developing worms were left undisturbed with the male until the larvae abandoned the parent tube. At this stage the larvae could be pipetted into separate petri dishes containing *Enteromorpha* sp. At first many larvae could be placed within the same dish, but as the worms grew they became cannibalistic and had to be separated.

A second method (Reish, 1953), but not as successful, was to place the bottom half of the petri dish containing a male and developing larvae into a one gallon aquarium. One liter of sea water was placed in the aquarium; the water was aerated by an aquarium stone connected to a compressed air system. Dried, ground *Enteromorpha* sp. was added twice a week. This technique was particularly useful for maintaining small larvae for a short period of time.

The Fighting Reaction

The sexes cannot be distinguished morphologically prior to the onset of sexual maturity. Females may be separated from immature females or males by the presence of developing ova in the coelom. Only by studying the reactions of sexually unknown specimens to known males or females could the males be distinguished. Herpin (1923; 1926) found that a female would readily accept a male but would fight off the introduction of a second female. These observations were confirmed by the author. Not only was it found that females would fight one another, but also a similar response occurred when two males were placed together. This behavior, which is termed the fighting reaction, is so definite that it was utilized to differentiate the sexes.

The fighting reaction is most pronounced when two worms of the same sex meet directly. Each proboscis is everted and the jaws extended to grasp the opposing animal. One such encounter lasts only a few seconds, but successive encounters may extend over an interval of several minutes. Termination of these fighting periods occurred when the worms became separated a few centimeters from one another. When one animal came in contact with any portion of the body of the second one other than its anterior end, it extended its jaws and attempted to grasp the worm. No injuries have been actually seen inflicted by this fighting, but when similar sized worms of the same sex were left together for a day, wounds were observed the next day. One or both of the animals lacked its posterior end, the remains of which appeared in fecal pellets. If the two worms were of the same sex but differed in size and were left together for a day, the larger worm usually will have eaten the smaller by the next day. This fighting reaction may account for the difficulty of culturing several worms within the same petri dish as discussed above.

A modification of this fighting reaction was observed in the male following egg-laying by the female. A male incubating eggs will frequently eat the spent female. A spent female will fight with a second female that has not yet laid her eggs. A male incubating eggs will fight with worms of either sex. After completion of the incubation period, the male will no longer fight with a female.

The basic behavior pattern appears to be an attraction to members of the opposite sex and a fighting reaction to members of the same sex. This pattern is altered in the male while incubating ova; he fights either sex. This behavior difference during the incubation period is apparently due to the presence of the eggs, although it was not the subject of any special investigation. Apparently there is no change in the behavior of the female during its life cycle.

Incubation of eggs is known to occur in *Micronereis variegata* (Rullier, 1954), *M. nanaimoensis* (Berkeley and Berkeley, 1953), *Platynereis massiliensis* (Hauenschild, 1951), *Laeonereis glauca* (Herpin, 1929), and *Cera-*

tonereis costae (Durchon, 1956), but it is not known whether or not this fighting reaction occurs in these species.

REPRODUCTION AND DEVELOPMENT

Sex Ratio

As reviewed by the author (1954), little is known concerning the sex ratio in the nereids. A ratio of one to one exists in *Nereis grubei* (Reish, 1954) on the basis of laboratory-reared specimens and field collections. Population studies showed a ratio of five males to four females in *Perinereis nuntia* var. *brevicirris* Grube (Takahasi, 1933), and 40 per cent males in *Nereis diversicolor* from South Baltic Sea (Bogucki, 1954) but only 10 per cent from the southern English coast (Dales, 1950).

Specimens of *N. caudata* were isolated into individual petri dishes shortly after they had left the parent tube. These worms were observed periodically for signs of egg formation. Those specimens which did not develop eggs were placed separately into a dish containing a female. The behavior of these worms was observed when they came in contact with one another. If the animals did not fight, then the unknown was considered a male. If the animals did fight, then the unknown was considered to be a female. The worms were then returned to separate petri dishes for further observations. No changes in the response to the fighting reaction were observed subsequently. A total of 170 specimens were isolated in this manner; they were offspring from six different matings. The results indicated a sex ratio of one to one; there were 88 females and 82 males.

Spawning

Spawning has never been observed in *N. caudata*. It has been described for several species of epitokal nereids (Reish, 1954) and in *Nereis diversicolor* (Bogucki, 1954). In *N. diversicolor*, a non-epitokal form, Bogucki found that the eggs are released through ruptures in the body wall, and that sperm may be discharged either through the nephridia or through ruptures in the body wall.

Some details concerning spawning behavior in *N. caudata* can be given, however. A series of 10 dishes, each containing a male and female, were observed at hourly intervals during the day (but not the week end) for a three-week period. Eight of the ten pairs spawned during the period. In one instance the female laid all her eggs between one hour observational periods. In a second instance a female was seen that had laid about one-half of her eggs. It is not known whether or not she was in the act of laying at the time of observation. She died three days later without laying any additional eggs. The remaining six pairs laid eggs either during the night or over the week end.

Freshly laid eggs of *N. caudata* were molded into a mucoid tube of one egg in thickness by the male. The male was undulating its body at all times. At first the eggs were free and easily withdrawn with a micropipette, but after the male had molded them into an egg tube, they became appressed and were difficult to remove with a micropipette. No gelatinous envelope (Hemplemann, 1911) surrounded the fertilization membrane as is typical for the epitokal nereids.

No sperm were observed in the water during placement of the eggs by the male. No dissections were made of these males. Periodic coelomic smears of the posterior part of known males did not reveal the presence of any bodies that could be definitely attributed to sperm or spermatic masses. Sperm was seen embedded within the space between the fertilization membrane and the developing ovum by Herpin (1926, fig. 115) and the author.

Fate of the Parents

Herpin (1923; 1926) stated that following completion of the larval incubation period, the male resumed its former life, and in one instance a male would reproduce a second time. The fate of the female was unknown except in one instance where Herpin noted

that the male had eaten the female the day following egg-laying.

The observations of Herpin were confirmed, and the following additional details can be given. The female either died after egg-laying or was eaten by the male. This cannibalistic action by the male is believed to be incidental because the fate of the female was approximately equally divided between the two causes. One female lived a total of six days following egg-laying, but this was exceptional. Typically the female lives two or three days after laying her eggs before dying. The females ate *Enteromorpha* sp. until a day before egg-laying, but none of them resumed feeding after spawning.

After the larvae have left the tube of the parent, the male may also abandon the tube, but not necessarily. The male may reproduce and incubate larvae more than once. Many males have fertilized and incubated eggs two times and one male has successfully incubated eggs three times in the laboratory. How soon after completion of one incubation period the male can reproduce with a second female was not completely ascertained because of the lack of mature females at the critical time. The shortest period of time between two fertilization periods for one male was 27 days. The first eggs were fertilized on September 12, 1954, with all the larvae leaving the tube by September 22, 1954. The second female was placed with the male on October 4, 1954, with fertilization occurring October 8, 1954. *Neanthes caudata* is the only dioecious species of nereid known in which at least one of the sexes can reproduce a second time.

Number of Eggs

Little information on the number of eggs or larvae of nereids has been recorded in the literature. Smith (1950) stated that *Neanthes lighti* produced several hundred eggs but only 80 to 100 larvae were released. Rullier (1954) found that *Micronereis variegata* laid from 20 to 80 eggs in a gelatinous matrix. In *Nereis grubei* the author (unpublished data) found the number of eggs to vary from 1,000 to 49,000. The lower figures were generally for those animals reared in the laboratory, and the higher figures were from animals collected from nature.

The number of larvae of *N. caudata* hatching from the parent tube were counted rather than the eggs because of the greater ease in counting. This figure is believed to represent a close approximation of the actual number of eggs laid by the female since non-developing eggs were not seen. Only one count of larvae was made from a female collected from nature; a total of 481 larvae left the parent tube. Counts for seven laboratory-reared females ranged from 143 to 791, with a median of 365 larvae.

Fertilization and Early Development

The unfertilized ovum of *Neanthes caudata* is spherical and yellow (Fig. 1). Eggs from laboratory-reared females measured from 420 to 520 μ in diameter. The ova observed by Herpin (1926) were 600 μ in diameter, the largest size recorded for a nereid egg. No distinct cortical layer was observed.

The process of fertilization has not been observed either by Herpin or by the author. Eggs that had been laid within an hour al-

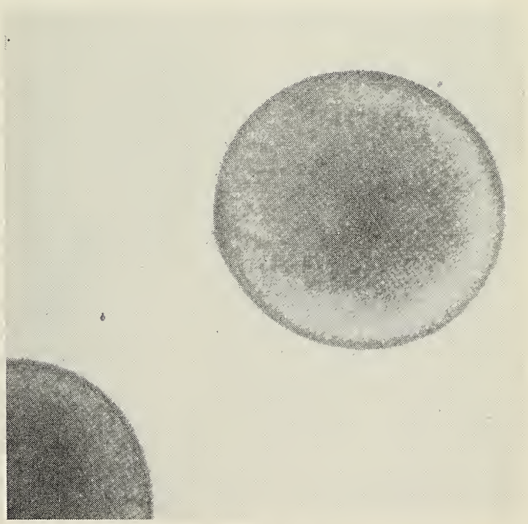

FIG. 1. Photomicrograph of an unfertilized egg of *Neanthes caudata*. Diameter, 425 μ.

ready possessed fertilization membranes. As stated above, sperm were observed embedded in the space within the fertilization membrane. Cleavage proceeded very slowly through the eight-cell stage. The cleavage pattern was spiral and similar to that described by E. B. Wilson (1892) for *Neanthes succinea* and *Platynereis dumerilii*. However, there was no further cleavage of the four yolky macromeres beyond this stage of development. These yolk cells will eventually become enclosed within the digestive tract and will be utilized for food (Figs. 2 to 7). These four cells can be seen until just prior to feeding.

Cleavage beyond the eight-cell stage was limited to the animal pole (Fig. 2, arrow). These cells come to surround the four macromeres by epibolic growth. The embryo was never ciliated, which is unique among the nereids.

The developing egg remained spherical until the seventh day when a slight elongation of the embryo was noted (Fig. 3). Longitudinal muscular movement appeared at this time. The course of growth from the elongation of the embryo through sexual maturity has been summarized in Table 2. Formation of the three larval segments occurred at eight days. The anal cirri appeared as knobs at this time, but there were no indications of cephalic appendages (Fig. 4). Shortly thereafter the larvae hatched from the egg capsule.

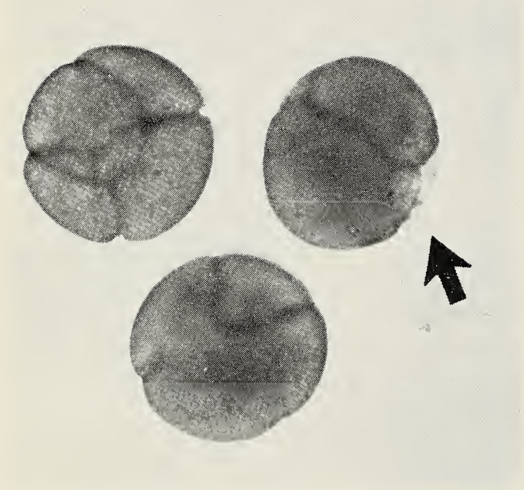

FIG. 2. Photomicrograph of developing embryos of about 18 hours in age showing the four macromeres. Arrow indicates site of cleaving micromeres. Diameter, 520 μ.

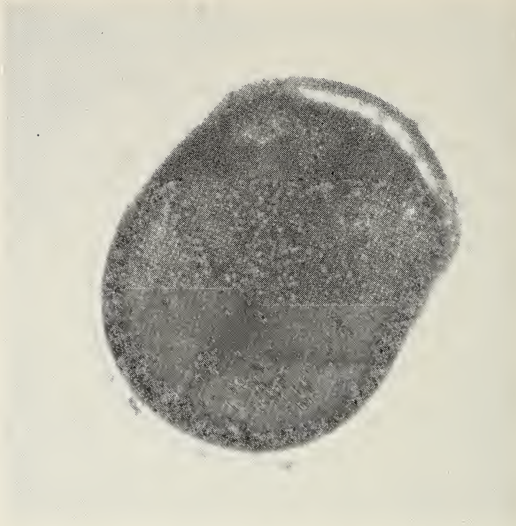

FIG. 3. Photomicrograph of an elongating embryo of seven days in age encased in egg capsule. Length, 520 μ.

During the ninth day the fourth larval setigerous segment, the first pair of peristomial tentacles, and the tentacles appeared. In addition, as many as four presumptive segments were often discernible as simple protuberances (Figs. 5 to 7). The four yolk-cells were still present, and because of their large size, they gave a humpback appearance to the larvae (Fig. 5). New segments were added rapidly until the animal had developed about 16 segments at 16 days (Figs. 5 to 8). The young worms, which have been crawling actively within the parent tube, begin to abandon the tube in the next few days. The larvae crawl about the petri dish, construct mucoid tubes, and begin to feed upon *Enteromorpha* sp. by 21 days. There is no true planktonic stage in *N. caudata*. However, if the young animals are disturbed, they abandon their tube and either crawl or swim away. This behavior may play an important role in the distribution of *N. caudata*, particularly within a bay or

harbor. One specimen with 18 setigerous segments was taken in a plankton tow on October 21, 1954, in Los Angeles inner harbor. Further appearance of segments is indicated in Table 2.

The tentacles and first pair of peristomial tentacles appear as small knobs on the ninth day. The next two pairs of peristomial tentacles arise in the next two days (Fig. 5). The fourth pair was slow to appear; it did not form until the larva was 23 days of age and possessed 24 segments. The palpi were seen first at 10 days (Fig. 5) and became biarticulated a few days later.

The jaws were noticed when the larvae were 10 days old. They were colorless structures and consisted of only the terminal tooth. The first lateral tooth was added by the next day. Additional lateral teeth were formed rapidly; a larva 21 days old had 7 teeth. The tips of the jaws became dark brown at this time. Lateral movements of the jaws did not occur until the larvae had 15 segments, or just prior to leaving the parent tube.

Paragnaths were seen first on the maxillary ring at 14 days; they did not appear on the oral ring until 21 days. The paragnaths became dark brown at about 26 days when the animals possessed 32 segments. Figure 9 is a photomicrograph of the paragnaths of area I. A total of 37 paragnaths was observed in this specimen, which was a typical number for young worms. Adult worms reared in the laboratory had from 12 to 16 paragnaths present, indicating a loss in number with age. This was contrary to what was observed by the author (1954) in *Nereis grubei*, which showed little change, if any, with age.

FIG. 4. Photomicrograph of a three-segmented larva of eight days in age. The anal cirri are beginning to develop as small knobs at the right side of the figure. Length, 750 μ.

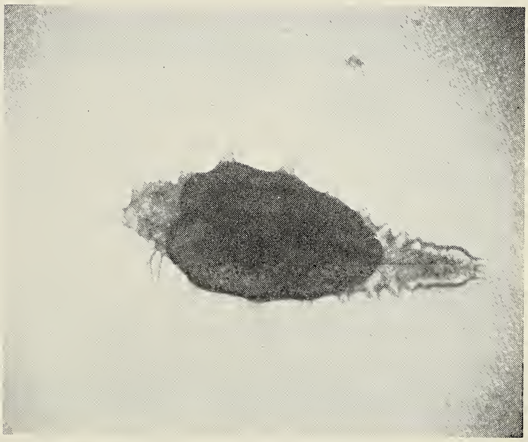

FIG. 5. Photomicrograph of five-setigerous segmented larva 10 days old. Shown in formation (from left to right) are the tentacles, palpi, two pairs of peristomial tentacles, five setigerous segments, four segments without setae, and one pair of anal cirri. Length, 1.1 mm.

The development of *N. caudata* collected at Cherbourg, France (Herpin, 1926), and Los Angeles Harbor, California, does not differ in morphological details, only in regard to time of appearance of structures. The three larval setigerous segments arose a day earlier at Cherbourg. This difference in one day continued until about 10 to 11 days when larvae from both localities possessed six larval segments. However, in the Los Angeles Harbor

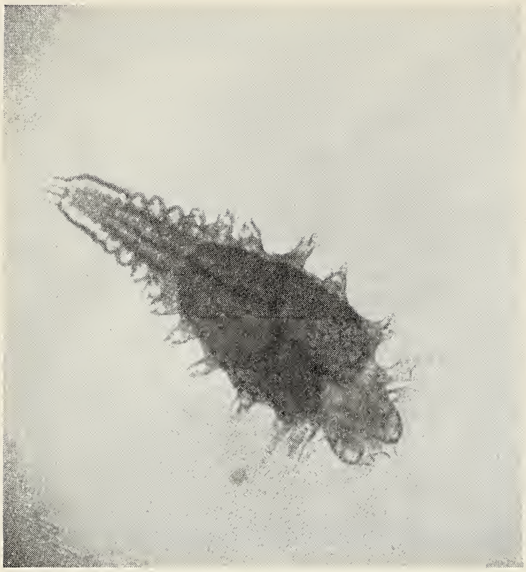

FIG. 6. Photomicrograph of seven-setigerous segmented larva 11 days old. Appendages as in Figure 5. Note the humpback appearance of the animals in Figures 5 and 6. Length, 1.1 mm.

material the 20-segmented stage was attained about eight days before the Cherbourg population.

Later Stages of Growth

Growth in the later stages of development in the nereids has been measured in three different ways. The use of segment number per unit of time has been employed most frequently (Banse, 1954; Bogucki, 1954; Dales, 1950; Hauenschild, 1951; Hemplemann, 1911; Herpin, 1926; Rullier, 1954; and D. P. Wilson, 1932). Body length was utilized by Bogucki (1954), Dales (1951), and Smidt (1951). The weight of the animal was determined periodically and correlated with metamorphosis and the appearance of genital products in *Nereis grubei* by the author (1954). With the former two methods, a sigmoid curve for growth was obtained. Similar results were attained for *N. grubei* when the number of segments per unit time was plotted (Fig. 8) using the data given by Reish (1954).

Growth in *Neanthes caudata* was followed by determining the number of segments present per unit time; the results have been summarized in Table 1 and plotted in Figure 8. The data are based on the growth of the offspring of one mating. Observations upon living specimens are difficult to make since they move about continually within their tube. The activity of these animals was slowed by placing the petri dish within an ice bath.

It is readily observable that growth in *N. caudata* differs from *Nereis grubei*. The appearance of the three larval setigerous segments lags in *N. caudata*, but the attainment of additional segments in *N. caudata* soon surpasses *Nereis grubei*. However, a plateau is reached at the time the larvae of *N. caudata* leave the parent tube and commence feeding at the 17- to 19-setigerous segment stage (Fig. 8; Table 1). Shortly thereafter a second growth spurt occurs which continued until the eggs were first discernible in the females at around the 55-segment stage. A few additional segments were added during the next 10 to 15 days. The maximum number of

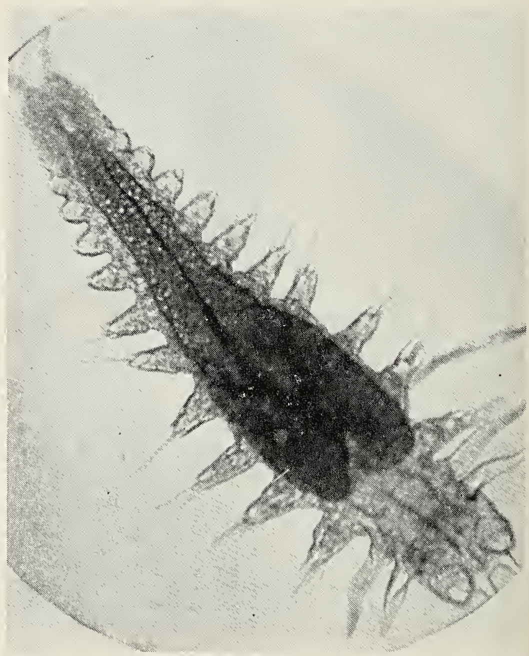

FIG. 7. Photomicrograph of eight-setigerous segmented larva 12 days old. Appendages as in Figure 5. Length, 1.2 mm.

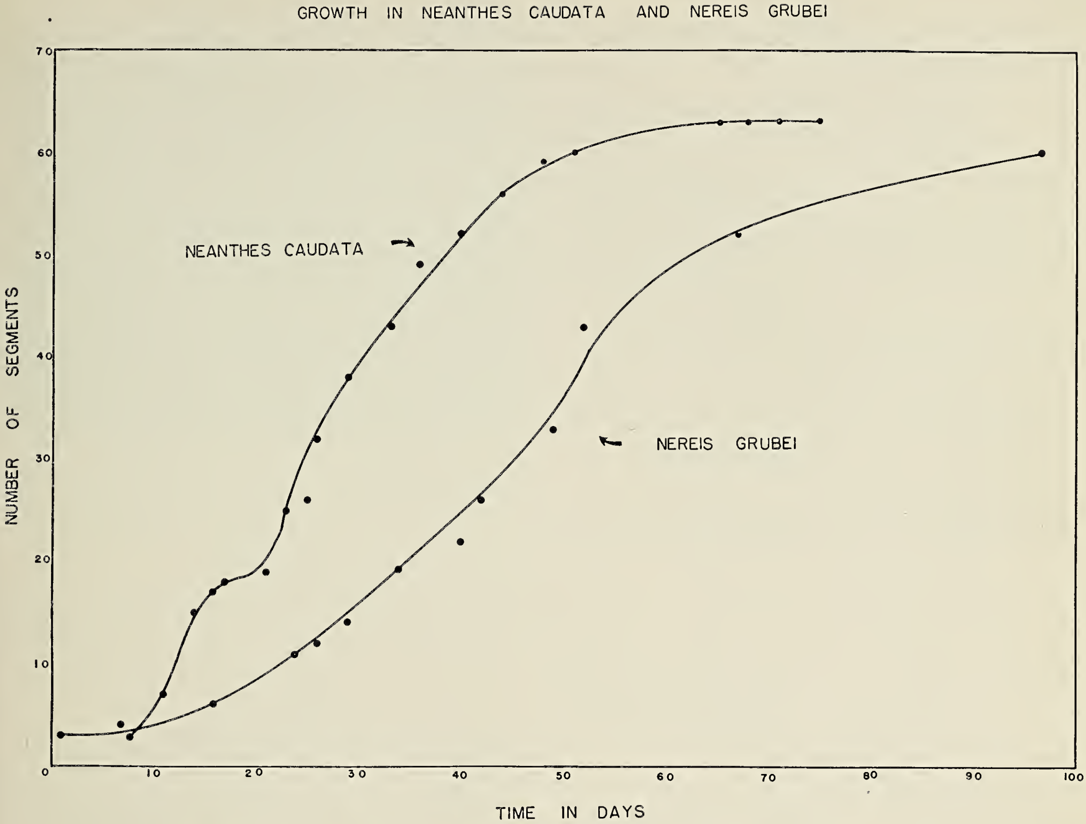

FIG. 8. Growth in *Neanthes caudata* and *Nereis grubei* as measured by the number of segments per unit time. Data for *Nereis grubei* taken from Reish (1954: 16).

segments were attained about 10 days before spawning. No sexual differences were noted with regard to the appearance or number of segments, and there was no indication that the males increase their number of segments between their first and second reproductive periods.

So far as is known, there seem to be two types of growth curves in the nereids when the appearance of segments is used as the unit of measurement. *Neanthes caudata* possesses a sigmoid growth curve with an interrupted plateau occurring at the onset of feeding. There is no initial prolonged phase after the appearance of the three larval segments in *N. caudata*, as is typical for the majority of nereids. It is possible that *N. lighti* is characterized by an interrupted growth curve. A similar initial spurt as in *N. caudata* was found when the data from Smith (1950) was plotted. Development of *N. lighti* was not followed after birth by Smith. As summarized in Table 1, several nereids incubate their young, but either data were not included or development was not continued far enough to ascertain whether or not these species possess a growth curve similar to *N. caudata.*

Sexual maturity was reached in 65 days (Table 2) with the female laying her eggs, and the male incubating them. The F_2 generation reproduced 148 days later, and the F_3 generation reproduced 203 days later. Five generations have completed their life cycle in the laboratory within a period of one year. No gross morphological differences between the different matings or generations were

TABLE 1

REVIEW OF REPRODUCTION AND DEVELOPMENT IN FAMILY NEREIDAE

SPECIES	METHOD OF REPRODUCTION	MAXIMUM STAGE REARED	REFERENCE
Ceratonereis costae (Grube)	Eggs laid in jelly mass in tube; eggs incubated by ♀	37 day old larva had 6 larval segments	Durchon, 1956
Micronereis nanaimoensis Berkeley and Berkeley	Swarming and pairing but not epitokal; eggs laid in jelly mass with ♂ incubating	23 day old larvae possessed 3 larval segments	Berkeley and Berkeley, 1953
M. variegata Claparède	As *M. nanaimoensis*	40 day old larvae possessed 6 segments	Rullier, 1954
Namanereis indica (Southern)	Protandric hermaphrodite	Preliminary note only	Aiyar, 1935
N. raneuensis (Feuerborn)	Hermaphroditic	4 day old larva possessed 3 larval segments	Feuerborn, 1932
Neanthes caudata (delle Chiaje)	Eggs laid in tube; eggs incubated by ♂	Sexual maturity in 2 months; ♂ reproduced more than once; ♀ reproduced only once	Reported herein
N. japonica (Izuka)	Swarming but not epitokal	9 day old larva had 4 larval segments	Izuka, 1908; 1912
N. lighti Hartman	Viviparity and probably self-fertilizing hermaphrodite	Parturation occurred at 3–4 weeks of larvae with up to 30 segments	Smith, 1950
N. succinea (Frey and Leuckart)	Epitoky	60 day old larva had 17 segments	Banse, 1954
Nereis diversicolor Müller	Direct; population 40% ♂ in Baltic Sea and 10% ♂ on English coast	Sexual maturity reached in 10 months	Bogucki, 1954; Dales, 1950
N. grubei (Kinberg)	Epitoky	Sexual maturity in 3.5 months; offspring all epitokal	Reish, 1954
N. irrorata (Malmgren)	Epitoky	3 larval segments	Herpin, 1926
N. pelagica Linnaeus	Epitoky	One year old specimen had 60 segments	D. P. Wilson, 1932
N. procera Ehlers	Epitoky	Reared to sexual maturity but no details given	Guberlet, 1934*b*
N. vexillosa Grube	Epitoky; eggs laid in jelly mass; no incubation	One specimen was 13 months old but not sexually mature at time of death	Johnson, 1943
Perinereis cultrifera (Grube)	Epitoky	45 day old larva had 7 segments	Herpin, 1926
P. marioni (Audouin and Milne-Edwards)	Epitoky	80 day old larva had 19 segments	Herpin, 1926
Platynereis bicanaliculata (Baird)	Epitoky	Sexual maturity in 9 months; offspring all epitokal	Guberlet, 1934*a*
P. dumerilii (Audouin and Milne-Edwards)	Epitoky	Sexual maturity in 21 weeks; offspring all epitokal	Hauenschild, 1951
P. massiliensis (Moquin-Tandon)	Protandric hermaphrodite; ♂ incubates eggs	Sexual maturity; sperm present when worm had 17–25 segments; eggs present when worm had 41–47 segments	Hauenschild, 1951

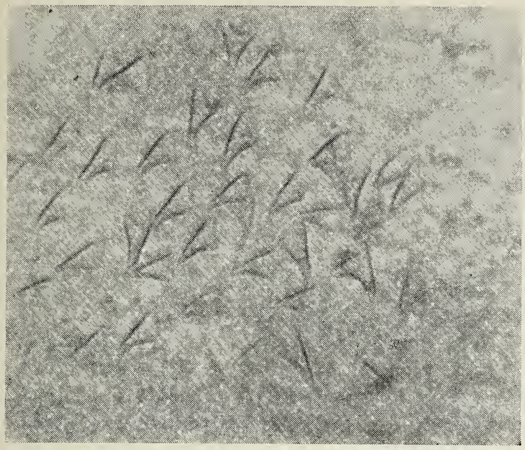

FIG. 9. Photomicrograph of colorless paragnaths on area I of a 17-segmented worm 17 days old. Dimensions top to bottom of area I, 70 μ.

TABLE 2
SEQUENCE OF EVENTS IN THE LIFE HISTORY OF *Neanthes caudata*

AGE IN DAYS	CHARACTERISTICS
7	Elongation of egg; muscular movement; length 0.52 mm.
8	Appearance of three larval segments; anal cirri; hatching from egg capsule; length 0.62 mm.
9	Four larval segments; tentacles; one pair of peristomial tentacles; length 1.0 mm.
10	Five larval segments; two pairs of peristomial tentacles; early palpi; jaws with terminal tooth only; length 1.1 mm.
11	Seven larval segments; three pairs of peristomial tentacles.
13	Animals with 12 adult segments; setae of first larval segment drop out, segment becomes peristomium; jaws with four lateral teeth; length 1.4 mm.
14	Animals with 14 segments; jaws with five lateral teeth; paragnaths on maxillary ring only.
16	Animals with 16 segments; jaws with six lateral teeth.
21	Animals with 18 segments; jaws with seven lateral teeth; jaws becoming dark brown at tips; paragnaths present on oral ring; worms have left parent tube and have built own mucoid tube; length 4.0 mm.
23	Animals with 24 segments; four pairs of peristomial tentacles; feeding; length 6.0 mm.
26	Animals with 32 segments; paragnaths getting dark brown.
33	Animals with 42 segments.
36	Animals with 48 segments.
40	Animals with 51 segments.
44	Animals with 55 segments; eggs observed in coelom.
65	Female lays eggs with male incubating.
92	Male fertilized eggs from second female.
148	F_2 generation reproduced.
203	F_3 generation reproduced.

noted; however, a statistical analysis of the offspring was not the subject of any special study.

DISCUSSION

A review of the literature on nereid development (summarized in Table 1, which gives the method of reproduction, the maximum stage to which the species has been reared, and the most recent reference) shows many different reproductive methods but apparently only two patterns of development. The most common method of reproduction is through epitoky. In this method the worms abandon their tubes or burrows at maturity and the sexual elements are emptied directly into the water, where fertilization and development ensue. These ova give rise to planktogenic larvae (Hemplemann, 1911). Both male and female die after spawning. This form of reproduction has been observed and studied in *Neanthes succinea*, *Nereis grubei*, *N. irrorata*, *N. pelagica*, *N. procera*, *N. vexillosa*, *Perinereis cultrifera*, *P. marioni*, *Platynereis bicanaliculata*, and *P. dumerilii*. *Nereis vexillosa* deviates slightly from the pattern in that the eggs are laid in a gelatinous egg mass, rather than singly.

Swarming, without epitoky, followed by pairing and egg-laying, has been observed in *Micronereis variegata*, *M. nanaimoensis*, and *Neanthes japonica*. In the two species of *Micronereis*, the female lays the eggs in a gelatinous mass on the substrate and incubates them until the larvae emerge from the matrix. Fertilization takes place in the water mass in *N. japonica*.

The female of *Ceratonereis costae* lays her eggs in a gelatinous matrix within her tube. Neither epitoky nor swarming precedes egg-

laying in the population in Algeria. The eggs are incubated by the female (Durchon, 1956).

The larvae of *Nereis diversicolor* and *Neanthes lighti* resemble those species given above, but differ in their site of development. This proceeds on the substrate in *N. diversicolor* (Dales, 1950) and in the coelom of viviparous *N. lighti* (Smith, 1950).

Only two of the species studied have eggs with a large amount of yolk, giving rise to nereidogenic larvae. In both of these species, the male incubates the eggs within a mucoid tube, a ciliated embryonic stage is lacking, there is no larval planktonic stage, and the adults do not undergo metamorphosis into epitoky prior to sexual maturity. One of these two species, *Platynereis massiliensis*, has been studied by Hauenschild (1951) who found it to be a protandric hermaphrodite. The other is *Neanthes caudata*, whose life history is discussed in this paper.

It certainly appears from this summary that the method of reproduction and development of *Neanthes caudata* is unusual among the nereids. But only a few species have been studied and there is too little information available as yet to make any positive statement on this subject. As no correlation is apparent between genera and mode of reproduction, the life history of each species must be worked out before any authoritative conclusions can be reached.

SUMMARY

1. Reproduction and development in the polychaete family Nereidae was reviewed and summarized in Table. 1.
2. *Neanthes caudata* was reported from the Pacific Ocean for the first time. It was taken from suspended sediment bottle collectors and from the bottom of Los Angeles–Long Beach Harbors.
3. Techniques for rearing *N. caudata* through sexual maturity were described.
4. Males and females are attracted to one another, whereas individuals of the same sex fight with one another. This behavior is altered in the male while he is incubating the developing ova; he fights either sex.
5. A sex ratio of one to one was found in laboratory-reared specimens.
6. Spawning was not seen. The female died or was eaten by the male following egg-laying. The male incubated the eggs within its mucoid tube. The male may reproduce more than once.
7. The ova ranged in size from 420 to 520 μ in diameter. Fertilization was not observed. Cleavage proceeded very slowly. The four macromeres did not undergo further cleavage beyond the eight-cell stage. The micromeres continued to divide and gradually surrounded the macromeres by epibolic growth. The embryo was not ciliated. The three larval segments with setae appeared at eight days. The larvae left the parent tube at 21 days. Feeding commenced shortly thereafter. Sexual maturity was reached in both sexes in 65 days. The F_2 generation reproduced 83 days later and the F_3 generation 65 days later still. The sequence in the life history was summarized in Table 2.
8. *Neanthes caudata* was characterized by a sigmoid growth curve with an interrupted plateau, when the number of segments was used as a measure of growth. The interrupted plateau was correlated with the onset of feeding.

REFERENCES

AIYAR, R. GOPALA. 1935. Hermaphroditism in *Lycastis indica* (Southern). *Current Sci. [India]* 3: 367–368.

ANONYMOUS. 1952. Los Angeles–Long Beach Harbor pollution survey. *Los Angeles Regional Water Pollution Control Board No. 4, Calif.* 43 pp.

BANSE, KARL. 1954. Über Morphologie und Larvalentwicklung von *Nereis* (*Neanthes*) *succinea* (Leuckart) 1847. (Polychaeta erran-

tia.) *Zool. Jahrb., Abt. f. Anat. u. Ontog. Tiere* 74(1): 160–171.

Berkeley, Edith and Cyril. 1953. *Micronereis nanaimoensis* n. sp.: with some notes on its life-history. *Canad. Fisheries Res. Bd., Jour.* 10(2): 85–95.

Bogucki, M. 1954. Rozrod i rozwoj wieloszczeta *Nereis diversicolor* (O. F. Müller) w Baltyku. *Polskie Arch. Hydrobiol.* 1: 79–87. [With English summary.]

Dales, R. Phillips. 1950. The reproduction and larval development of *Nereis diversicolor* O. F. Müller. *Mar. Biol. Assoc. Plymouth, Jour.* 29: 321–360.

——— 1951. An annual history of a population of *Nereis diversicolor* O. F. Müller. *Biol. Bul.* 101: 131–137.

Day, J. H. 1953. The Polychaet Fauna of South Africa. Part 2. Errant species from Cape shore and estuaries. *Natal Mus. Ann.* 12: 397–441.

Durchon, Maurice. 1956. Mode de reproduction et développement de *Nereis* (*Ceratonereis*) *costae* Grube (Annélide Polychète a Alger. *Arch. de Zool. Expt. et Gén.* 93: 57–69.

Fauvel, Pierre. 1923. Polychètes errantes. *Faune de France* 5: 1–488. Paris.

Feuerborn, H. J. 1932. Eine Rhizocephale und zwei Polychaeten aus dem Süsswasser von Java und Sumatra. *Internl. Ver. theoret. Limnol. Stuttgart, Verhandl.* 5: 618–660.

Guberlet, John E. 1934*a*. Observations on the spawning and development of some Pacific annelids. *Fifth Pacific Sci. Cong. Canada, Proc.* 5: 4213–4220.

——— 1934*b*. Life history studies on some Pacific annelids. *Anat. Rec.* 60 (suppl.): 58–59.

Hauenschild, C. 1951. Nachweis der sogenannten atoken Geschlechtsform des Polychaeten *Platynereis Dumerilii* Aud. et M.-Edw. als eigene Art auf Grund von Zuchtversuchen. *Zool. Jahrb., Abt. f. Allg. Zool. u. Physiol. Tiere* 63: 107–128.

Hemplemann, Friedrich. 1911. Zur naturgeschichte von *Nereis dumerilii* Aud. et Edw. *Zoologica* [*Stuttgart*] 25(62): 1–135.

Herpin, R. 1923. Etiologie et développement de *Nereis* (*Neanthes*) *caudata* delle Chiaje. *Acad. des Sci. Paris, Compt. Rend.* 177: 542–544.

——— 1924. La ponte et la développement chez quelques Néréidiens et Syllidiens. *Assoc. Franç. pour l'Avanc. des Sci., Compt. Rend.* 47: 558–562. Paris.

——— 1926. Recherches biologiques sur la reproduction et le développement de quelques Annélides polychètes. *Soc. des Sci. Nat. de l'Ouest France, Bul.* Ser. 4, 5: 1–250.

——— 1929. Étude sur les essaimages des Annélides polychètes. *Bul. Biol. de la France et Belg.* 63: 85–94.

Izuka, Akira. 1908. On the breeding habit and development of *Nereis japonica* n. sp. *Annot. Zool. Jap.* 6: 295–305.

——— 1912. The errantiate Polychaeta of Japan. *Tokyo Imp. Univ. Col. Sci. Jour.* 30 (2): 1–262.

Johnson, Martin W. 1943. Studies on the life history of the marine annelid *Nereis vexillosa*. *Biol. Bul.* 84: 106–114.

Reish, Donald J. 1953. Description of a new technique for rearing polychaetous annelids to sexual maturity. *Science* 118: 363–364.

——— 1954. The life history and ecology of the polychaetous annelid *Nereis grubei* (Kinberg). *Allan Hancock Found., Occas. Paper No. 14.* 75 pp.

Rullier, F. 1954. Recherches sur la morphologie et la reproduction du Néréiden *Micronereis variegata* Claparède. *Arch. de Zool. Expt. et Gén.* 91: 197–233.

Smidt, E. L. B. 1951. Animal production in the Danish Waddensea. *Komm. Danmarks Fisk.-Havundersøgelser, Ser. Fiskeri., Meddel.* 11(6): 1–151. [Also in: *Skalling-Laboratoriet, Meddel.* 11: 1–151.]

SMITH, RALPH I. 1950. Embryonic development in the viviparous polychaete *Neanthes lighti*. *Jour. Morph.* 87: 417–466.

TAKAHASI, SADAO K. 1933. On the epitocous phase of the nereid, *Perinereis nuntia* var. *brevicirris* Grube. *Annot. Zool. Jap.* 14: 203–209.

THORSON, GUNNAR. 1946. Reproduction and larval development of Danish marine bottom invertebrates, with special reference to the planktonic larvae in the Sound (Øresund). *Komm. Danmarks Fisk.-Havundersøgelser. Ser. Plankton, Meddel.* 4: 1–523.

WILSON, DOUGLAS P. 1932. The development of *Nereis pelagica* Linnaeus. *Mar. Biol. Assoc. Plymouth, Jour.* 18: 203–217.

WILSON, EDMUND B. 1892. The cell-lineage of *Nereis*. A contribution to the cytogeny of the annelid body. *Jour. Morph.* 6: 361–466.

Records of Bioluminescence in the Ocean[1]

BRIAN P. BODEN and ELIZABETH M. KAMPA[2]

DURING THE MONTH of June, 1955, while measurements were being made of the depth of penetration of moonlight into the sea off the Kona Coast (S. W. coast) of the island of Oahu in the Hawaiian group, some information was obtained on bioluminescence in deep water in this region and on the effect of moonlight on the vertical distribution of luminescent organisms. Observations of bioluminescence were also made off San Diego, California, during the month of January, 1956.

An underwater photometer (Kampa, 1955; Snodgrass *et al.*, 1957 in press) designed for work in the deep sonic-scattering layers was used for these measurements. This was equipped with a depth-indicator (Boden *et al.*, 1955) so that a precise knowledge of the depth of the instrument was available at all times. The instrument utilizes a 931-A photomultiplier tube oriented with the sensitive surface facing up. In front of this is a collimating tube at the base of which is a filter-holder for interference filters. The collimator ensures that the 5° useful angle of the filters is not exceeded. At the distal end of this tube is a diffusing plastic disc, which is a true Lambert-type collector—that is, under a uniform sky the intensity (I_θ) collected from the direction Θ would be

$$I_\theta = I_0 \cos \Theta.$$

Thus the instrument measures irradiance. The collimating tube and filter-holder are free-flooding. The dark-current level of the instrument changes less than 0.2 millivolts on the 0–10 millivolt recorder range through the temperature range 10–30°C. It fluctuates about 0.03 millivolts at any particular temperature. The instrument registers down to 1×10^{-6} μ watts/cm^2.

Observations of bioluminescence in surface waters were made off San Diego (Lat. 32° 38′ N., Long. 117° 35′ W.) on the morning of January 18, 1956.

The photometer was lowered with its sensitive surface pointed downward. The sky was cloudless and moonless, and the first cast was made immediately before the beginning of official twilight. Luminescence was clearly visible at the surface at this time, and porpoises were seen to leave bright trails of light in their wakes.

Flashes, or bursts of light, were observed by the instrument, and recorded on a Leeds and Northrup Speedomax recorder, from the surface to a depth of 60 meters. From a depth of about 25 meters downward the flashes were superimposed on the dark-current level of

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the instrument, and at times apparently single flashes reached a level of 2×10^{-3} μ watts/cm^2.

A later cast, with the photometer still pointed downward, revealed that at sunrise (0652 hrs.) the flashes were first recorded at a depth of about 110 meters.[3] All facts known to us indicate that these flashes are generated *in situ* and we interpret them as due to luminescent organisms, possibly both nekton and plankton.

Records of bioluminescence at depth were first made in Hawaii at midnight on the night of June 9, 1955. The moon, three days past the full, had just appeared over the mountains. Its angle of elevation at 2400 hours was 19°. The instrument was lowered without color filters, and total irradiance, as seen by the instrument, was recorded. The sky was partly cloudy, but the moon remained clear throughout the observations.

Figure 1 is a tracing of the actual recording made on the Leeds and Northrup Speedomax recorder. Total irradiance (H) at any depth was obtained from

$$n = k\,H = \int_0^\infty E\,S\,d\,\lambda,$$

where n = recorder reading, E = energy of the source through the wave-length interval $d\,\lambda$, S = relative spectral sensitivity of the photomultiplier tube through the wave-length interval, $d\,\lambda$ (300–700 mμ). The value of k was obtained by calibration of the entire instrument against a Bureau of Standards source. The inset shows the relative spectral sensitivity of the 931-A tube used.

The dark-current level of the photometer was reached at 200 meters. From about 50 meters downward numerous brilliant flashes of light were recorded.

At some depths, for example 120–130 meters and 150–170 meters, the background light level appears to have remained constant or to have increased rather than to have decreased with depth.

Many types of luminescent marine animals, e.g., euphausiids, generate a steady glow of light for limited periods in contrast with the discrete flashes produced by others (Harvey, 1940). Possibly the sustained light level (Fig. 1) on which the flashes are superimposed at depths of 120–130 meters and 150–170 meters was due to a background glow produced by concentrations of such types, or by numerous flashes at varying distances.

An alternative explanation of the flashes can be found by visualizing a distribution of steadily-glowing organisms similar to that of stars in the sky, and a flashlike increase in the level of light due simply to the instrument's approach to and retreat from a glow during its descent. The rate of descent of the instrument was about 32 meters/minute. For this to be the true explanation, the glows would have had to be about 1 meter of depth apart, for the frequency of the flashes was about 36/minute.

Many luminescent organisms flash brightly when irritated mechanically or chemically. It is impossible at present to determine whether the observed flashes were due to spontaneous luminescence or whether the luminescence was intensified by agitation of the animals by the instrument.

Four more casts were made, using narrow-band interference filters, during the forty-five minutes after midnight. The angle of eleva-

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[3] The possibility that these are artifacts due to instrument failure is to be considered. It is improbable that distortion due to pressure affected the circuitry, for the phenomenon was not observed when the instrument had been lowered to greater depths during daylight. It is improbable, too, that the effect could have been caused by water leakage, for moisture in the system has been shown to raise the dark current to such a high level that the recorder is immediately sent off scale. Furthermore the fact that color filters placed in the light-path reduced the amplitude of recorded flashes discounts the possibility that loose electrical connections were responsible. Another photometer, similar to the one employed here, has since shown that the flashes are not recorded when the sensitive element is covered but are when it is exposed immediately afterward at the same depth. Thus we believe that the instrument was sensing real light flashes.

Flashes of this nature could not have been caused by tilt of the instrument since it was pointed downward.

tion of the moon varied between 21° and 31° during this period. The interference filters employed were G. A. B. filters, manufactured in Liechtenstein, with half-peak band widths of about 10 mμ. Block filters are incorporated to reduce stray light and eliminate secondary transmission peaks. Peak transmissions, measured by a Beckman Model DU spectrophotom-

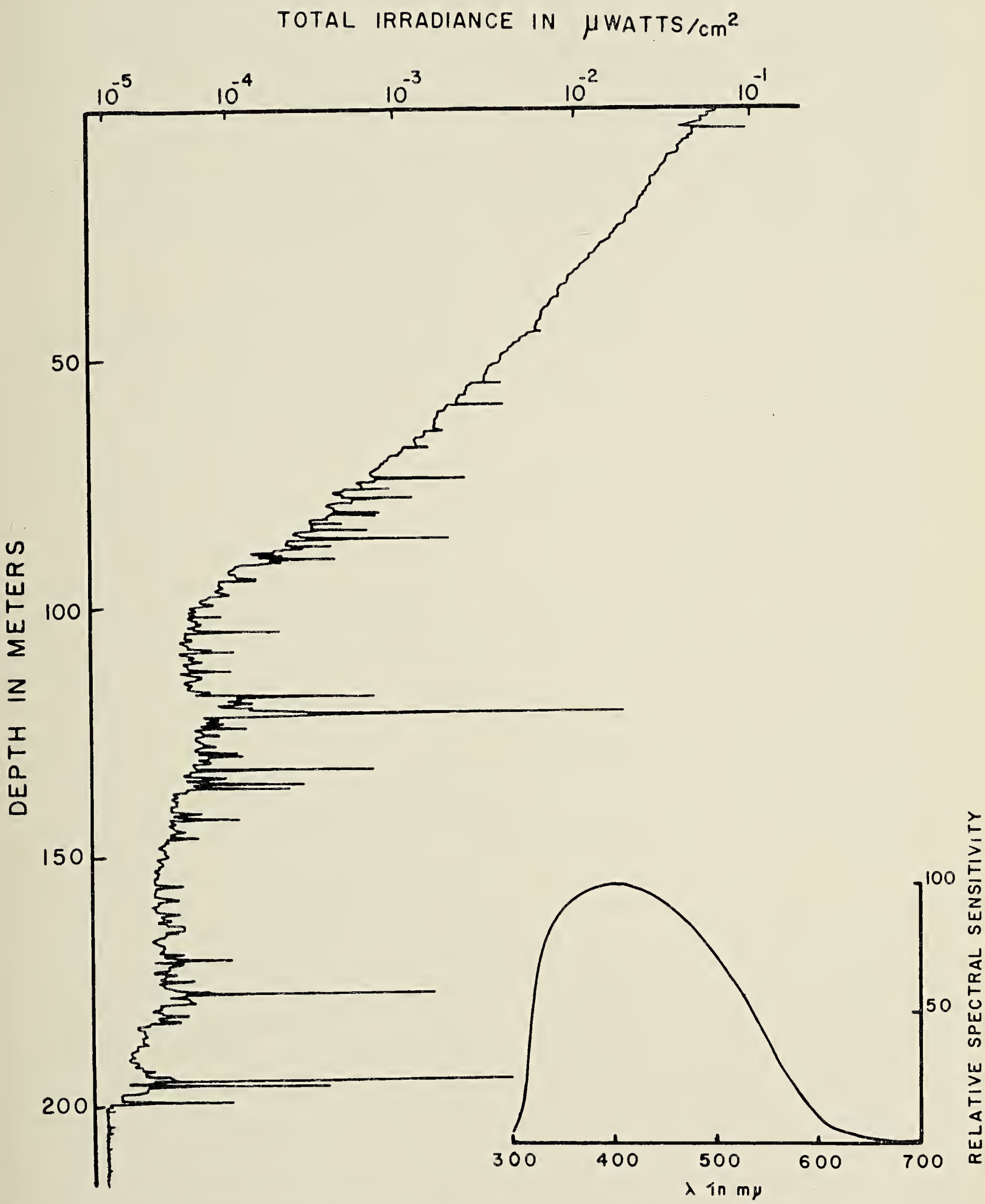

FIG. 1. Tracing of total irradiance recorded on Leeds and Northrup Speedomax recorder by bathyphotometer without color filters. Spectral sensitivity of the 931-A photomultiplier tube is shown in inset. This is from manufacturer's specifications and is an average curve. The record was made at 2400 hours, June 9, southwest of Oahu.

eter, are at 418, 491, 552, and 630 mμ (see inserts in Fig. 2).

Irradiance (H) was obtained from

$$n = k\,H = \int E\,T_f\,S\,d\,\lambda,$$

where n = recorder reading, E = energy of the source through the wave-length interval $d\,\lambda$, T_f = measured transmission of the individual interference filter through the wave-length interval $d\,\lambda$, and S = the relative sensitivity of the photomultiplier tube through the wave-length interval $d\,\lambda$. The value of k was obtained as indicated above.

Tracings of the recordings are shown in Figure 2. Orange light (λ max, 630 mμ) is seen to cut out at 11 meters, and no flashes are apparent. With the 418 mμ filter, the dark-current level of the instrument was reached at a depth of 280 meters.

The 418 mμ cast reveals an actual increase in irradiance with depth between 100 and 220 meters. Sudden flashes again occurred between 100 and 280 meters, but these, as recorded, were of lower amplitude than those in the unfiltered cast, presumably because of the narrowness and reduced intensity of the transmitted band.

These observations indicate that the light generated at depth is blue-violet (see Harvey, 1940, for spectral distribution of bioluminescence). It can be seen too (Fig. 2) that the flashes produced in the surface layers are greener.

The greater depth attained with a 418 mμ filter in the instrument (cf. Figs. 1 and 2) and the deeper flashes may be explained on the assumption that some of the light-generating constituents of the population had by then sought greater depths as the moon cleared the mountains and approached its zenith. The possibility that these constituents comprise a photoregulated community similar to the Californian deep-scattering layer may be inferred from this assumed downward migration with increasing illumination.

This inference is substantiated by observations made off San Diego (Lat. 32° 38′ N., Long. 117° 35′ W.) on January 17, 1956. At this time EDO fathograms and light measurements were made simultaneously during the periods of the twilight migration of the sonic-scattering layer. Figure 3A (1640–1650 hours) shows that flashes were first recorded as the photometer reached the depth of the scattering layer. Thirty minutes later (1720–1728 hours) the top of the scattering layer had reached a depth of 120 meters. Figure 3B shows that the first flashes recorded by the photometer were now at this same depth. On the day of these observations sunset was at 1706 hours.

We have recorded flashes, during our scattering-layer studies, in the Pacific, Atlantic and Mediterranean. They appear to increase both in frequency and amplitude during the twilight migration of the layer and at night. On this account it is extremely difficult to obtain an accurate picture of the spectral distribution of moonlight in the sea, or even of sunlight at scattering-layer depths.

Since the completion of this paper we have heard from Professor George L. Clarke of Harvard University (Clarke and Backus, in preparation) that he too has recorded flashes of luminescence off the Florida coast.

This phase of work on the sonic-scattering layers received additional support from the National Science Foundation and the Pauley Fund of the University of California. The inquiry was pursued from the Marine Laboratory of the University of Hawaii. The Californian data were obtained from the "USS EPCE(R) 855." Acknowledgment is made of the generous loan of the Research Vessel "Makua" by Mr. Vernon Brock, Director of the Territorial Fish and Game Commission, Hawaii. The U. S. Air Force and Marine Corps were unstinting in their loan of equipment and facilities. Data were analyzed and most of this paper was written at The Laboratory, Plymouth, England. The hospitality of the director, Mr. F. S. Russell, F. R. S., is most gratefully acknowledged. Professors

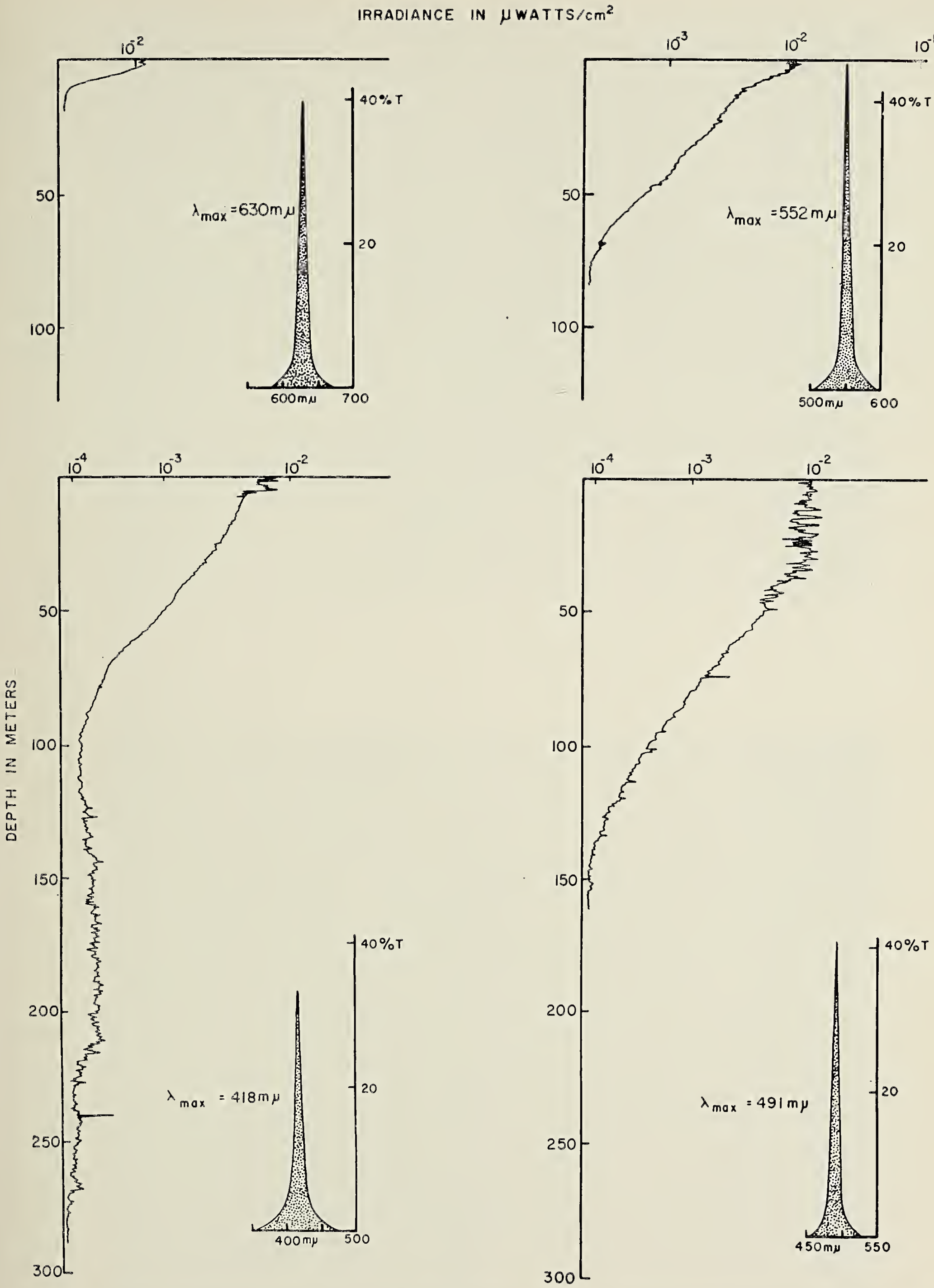

FIG. 2. Tracings of irradiance record at four different wave lengths as determined by bathyphotometer using interference filters. Insets show measured transmission curves of filters used. The records were made at the following times: 630 mµ—0020 hrs.; 552 mµ—0030 hrs.; 491 mµ—0044 hrs.; 418 mµ—0058 hrs.; all on June 10, southwest of Oahu.

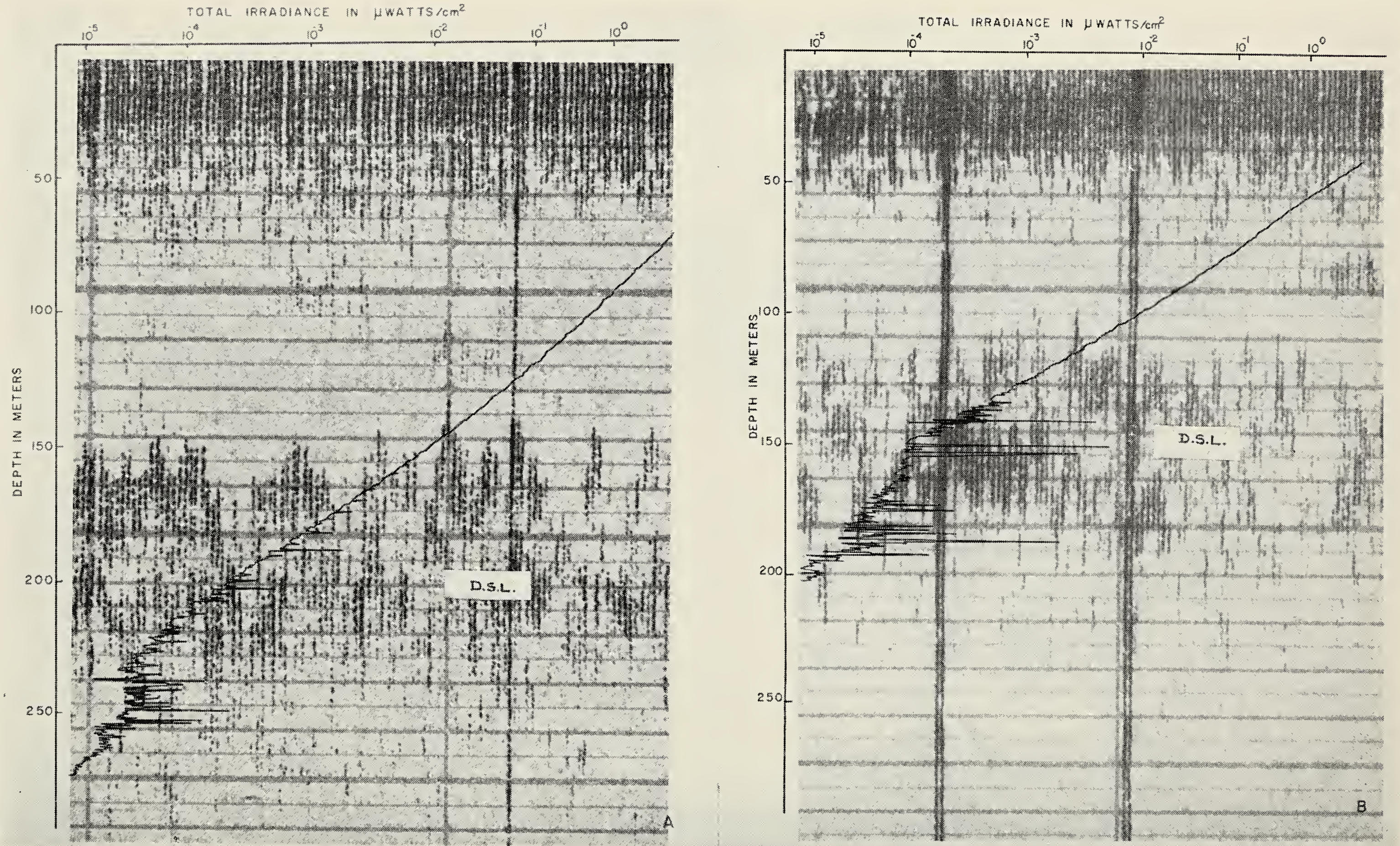

FIG. 3. Tracing of total irradiance recorded 17 January 1956, in the San Diego Trough, Latitude: 32° 38′ North; Longitude: 117° 35′ West. The superimposed fathograms were recorded at the same time. A: 1640–1650 hrs., B: 1720–1728 hrs. The light curve does not reach the surface because the upper limit of the photometer's range is about 2μ watts/cm².

Carl Eckart and Carl L. Hubbs of the Scripps Institution and Mr. John Tyler of the Visibility Laboratory of the Scripps Institution subjected the manuscript to vigorous and stimulating criticism.

REFERENCES

BODEN, BRIAN P., ELIZABETH M. KAMPA, JAMES M. SNODGRASS, and ROBERT F. DEVEREUX. 1955. A Depth Telerecording Unit for Marine Biology. *Jour. Mar. Res.* 14(2): 205.

CLARKE, G. L., and R. H. BACKUS. Light penetration in relation to vertical migration and records of luminescence of deep sea animals. *Deep Sea Research.* [In preparation.]

HARVEY, E. N. 1940. *Living Light.* Princeton University Press.

KAMPA, ELIZABETH M. 1955. A Discrepancy between Calculation and Measurement of Submarine Illumination. *Natl. Acad. Sci., Proc.* 41(11): 938.

SNODGRASS, J. M., R. F. DEVEREUX, and J. H. CAWLEY. 1957. A Telerecording Bathyphotometer. [In press.]

New Species and Records of Hawaiian Sponges

M. W. de Laubenfels[1]

Three previous papers on Hawaiian shallow-water sponges have appeared in *Pacific Science* (de Laubenfels, 1950, 1951, 1954). Repetition is here avoided, and it is assumed that the reader has consulted the earlier articles, especially that of 1950, on the sponges of Kaneohe Bay, Oahu. All of the sponges that are common about Oahu are described and named in that paper, and the key that is given there should be adequate. Further keys are inappropriate, because it is clear that almost any conceivable kind of sponge may be discovered in the next dredge haul. The present paper is based on three years' study, but it should be emphasized that even during the third year additional species were easily found.

Few references to the sponges of Oahu occur in the literature. Dr. C. H. Edmondson of the B. P. Bishop Museum in Honolulu has published (1946) on the reproduction of *Tethya*, but this is not a faunal paper. Casual references to sponges from Oahu occur, as discussed below, in some writings of Lendenfeld and Haeckel. A further reference may here be made to a paper by R. Baar (1903). He had a specimen "from Honolulu" that he identified (p. 30) as *Stelospongia lordii* Lendenfeld. Lendenfeld's species was a sponge from the Red Sea, and was described so vaguely that it might be a *Dysidea* or an *Ircinia*, or probably a *Polyfibrospongia*, but not even its generic allocation is clear. Baar's specimen was a macerated fragment that had lost all the significant bases for its identification. From his description one cannot even be sure to what family it belonged.

A bit of philosophy is indicated. Many sponge specimens are found in sea or on shore that cannot be identified. Often the sponge skeleton coheres for months after death, losing its characteristics bit by bit. Pathologic as well as moribund sponges get collected. Beach-worn skeletons flourish in museums. The author has been urged by museum authorities to identify EVERY specimen, when sound judgment indicated otherwise. Both Lendenfeld's and Baar's specimens above mentioned should have been frankly reported as unidentifiable, thus sparing the printer and reader alike.

DESCRIPTIONS OF SPECIES

Haliclona flabellodigitata Burton

The sponge thus identified was dredged 19 February 1948 from a depth of fifty meters, three kilometers south of Pearl Harbor. It was semi-incrusting, with convoluted lobes that were about 1 mm. thick. The entire sponge was not much more than 1 mm. thick, and covered an area about 1 cm. square. The color in life was whitish orange and the consistency was soft. The surface was not hispid, and (as is common in small sponges) no pores nor oscules were evident. There is no ectosomal specialization. The flagellate chambers are scattered, and generally about 35 microns in diameter. The skeleton comprises a few spic-

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ular tracts or fibers, with little spongin, only two to four spicules per cross section. The spicules are chiefly oxeas 2.5 to 3 by 160 microns. There are also numerous thinner spicules, 0.5 × 120 microns; these may be termed raphides, but on the other hand, may merely be juvenile forms of the larger spicules.

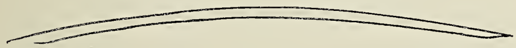

Fig. 1. Camera lucida drawing (× 635) of a typical spicule of the sponge identified as *Haliclona flabellodigitata.*

Burton (1934: 534) described *Haliclona flabellodigitatus* from northeastern Australia. His specimens, and that now under discussion, are notable within the large genus *Haliclona* for the relative thinness or slenderness of their oxeas. All *Haliclonas* are much like one another, and the question of "what is a species?" is even more perplexing in regard to this genus than for other genera. Spongologists are confident that many species of *Haliclona* exist, but for lack of striking characteristics have paid attention to small differences. It is far from certain that this Hawaiian sponge is conspecific with that described by Burton, but there is significant resemblance. It seems regrettable to add more and more new names in so crowded a genus, and therefore this tentative identification is made.

Xytopsues zukerani new species

This new name is based upon a single specimen, to be deposited in the U. S. National Museum, collected 14 February 1948 by dredging south of Diamond Head (Honolulu), at a depth of 75 meters. It was a small amorphous sponge, less than 1 cm. thick, less than 5 cm. in diameter. The color in life was orange, and the consistency of the soft sponge was obscured by its content of debris. There was no conspicuous dermal specialization, and the pores and oscules were closed,

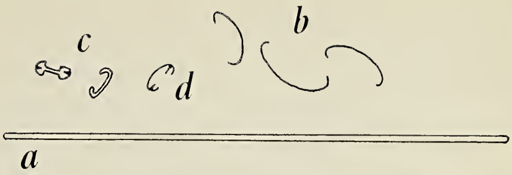

Fig. 2. Camera lucida drawing (× 635) of spicules of *Zytopsues zukerani*: *a*, Strongyle; *b*, sigmas; *c*, typical chela (arcuate) front and side views; *d*, a typical chela (unguiferate).

not evident. The sponge tissues held the mass together, but were otherwise confined to the interstices of a large quantity of calcareous sand. Some obviously foreign spicules were present, and in such cases as this it is always difficult (or impossible) to be sure which spicules are proper. The abundant, widely distributed ones are, however, probably proper. These include straight smooth strongyles 1.5 by 190 to 3 by 220 microns, contort sigmas 22 to 26 microns in chord length, and isochelas 12 microns long. The latter generally lie on one side in spicule preparations, as do palmate chelas that have narrow shovels. One isochela was found to be unguiferate, as illustrated in Figure 3*d*, but more seem to be arcuate, verging upon palmate, as shown in Figure 3*c*.

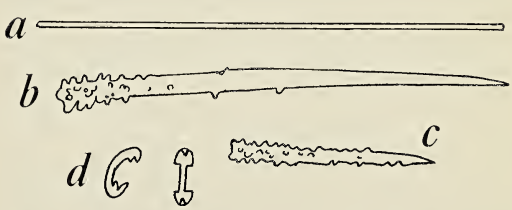

Fig. 3. Camera lucida drawing (× 635) of spicules of the sponge identified as *Lissodendoryx calypta*: *a*, Tornote; *b*, acanthostyle; *c*, echinating acanthostyle; *d*, arcuate isochela, side and front views.

The type of the genus *Xytopsues* was described as *Phoriospongia osburnensis* by George and Wilson (1919: 154) and transferred to *Xytopsues* by de Laubenfels (1936: 55). It was found at Beaufort, North Carolina. This western North Atlantic sponge is much like *X.*

zukerani except that its chelas have shafts that are pronouncedly curved, as in the letter "C." The other species already in *Xytopsues* was described as *Desmacidon griseus* by Schmidt (1870: 55). It is common in the West Indies and Bermuda, and is distinctive for its conspicuously unguiferate chelas. The species *zukerani* is thus characterized by its rather typically arcuate chelas and by its orange color. The name is given in recognition of the services to science of Lester Zukeran of the Hawaii Marine Laboratory.

Pellina sitiens Schmidt

The sponge thus identified was collected 29 March 1948 from a concrete dry dock at Pearl Harbor. It was out of water at the time of collection, but so placed as to be usually two or more meters under the surface. It covered an area about 5 × 7 cm. and consists mainly of oscular tubes 3 to 6 mm. in diameter; many of them attain a height of 2 cm. The walls of the tubes are paper-thin. The consistency is like that of wet paper. The surface is smooth, the pores not evident. The color in life was a pale dull yellow, the appearance well described as semi-transparent. The ectosome contained abundant spicules tangentially placed. The endosome was especially full of conspicuous flagellate chambers, round and 30 microns in diameter. The spicules are oxeas, chiefly in confused arrangements, and 15 × 450 to 12 × 480 microns in dimensions.

Ridley (1884: 414) described *Pellina eusiphona* from the Indian Ocean, and de Laubenfels (1954: 98) so identified a sponge from Ebon (Marshall Islands). The Hawaiian sponge is intermediate between that of the Western Pacific and Indian Ocean on the one hand, and the common North Atlantic species on the other hand. The latter was originally described as *Eumastia sitiens* by Schmidt (1870: 42). The Hawaiian specimen agrees in color with *sitiens*, and not with *eusiphona*, and it is possible that *eusiphona* should fall in synonymy with *sitiens*, although this step is not taken here. Another possibility, also rejected, but with misgivings, is that a new name might be needed for the Hawaiian *Pellina*.

Myxilla rosacea (Lieberkühn) Schmidt

This species has been reported from Kaneohe Bay (de Laubenfels, 1950: 17). The Hawaiian specimens there recorded were orange-red. On January 19, 1948 some others were found in Oahu with the clear red color that is characteristic of *Myxilla rosacea* elsewhere in the world.

Lissodendoryx calypta de Laubenfels

The sponge thus identified was dredged 14 February 1948 south of Diamond Head (Honolulu), Oahu, at a depth of about 30 meters. It was a thin incrustation, less than 1 mm. thick, of a rich carmine red color. The consistency was mediocre, the surface smooth, with no pores and oscules that could be certainly identified. The skeleton consists of spicules in confusion. There are straight smooth tornotes that may be regarded as ectosomal, 2 × 165 to 2.5 × 200 microns. The principal megascleres are acanthostyles 6×60 to 9×160 microns in dimensions. The smaller ones are spined throughout their entire length. The larger ones are smooth from the pointed end nearly halfway to the blunt end. The certain microscleres consist only of abundant isochelas of typical arcuate shape. Some extremely thin straight spicules may be raphides, but may more likely be juvenile tornotes.

Lissodendoryx calypta was described by de Laubenfels (1954*b:* 133) for a specimen from Eniwetok. It had smaller isochelas in addition to many like those in the Hawaiian specimen, and it lacked the larger acanthostyles, but the two agree in their lack of sigmas, lack of smooth styles, and thinness of incrustation.

Axechina lissa new species

This new name is based upon a single specimen, to be deposited in the U. S. Na-

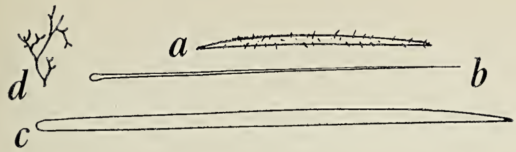

FIG. 4. Camera lucida drawing (× 635) of spicules of *Axechina lissa*: *a*, Microspined oxea; *b*, tylostyle; *c*, style; *d*, freehand sketch of the sponge × 0.3.

tional Museum, dredged 14 February 1948, near Koko Head, Oahu. It is ramose, with cylindrical dendritic branches 3 mm. in diameter, reaching a height of 7 cm. The color in life was a deep pink, which color was briefly transferred to the alcohol in which it was preserved. The surface is comparatively smooth, with no evident oscules, but with abundant pores each about 100 microns diameter, about 25 pores per square millimeter. There is a fleshy dermis about 20 microns thick. The spherical flagellate chambers are 25 to 30 microns in diameter. The endosome contains a reticulation of keratose fibers 12 to 30 microns in diameter, most commonly about 15 microns diameter. The smaller ones are cored by a single row of spicules, the large ones by as many as three spicules per cross section. The mesh of the reticulation is 50 to 100 microns in diameter, most often about 65 microns. The reticulation forms an axial core to the branches, about 1 mm. in diameter, but whereas it is generally a rather dense core, in places it opens to form a central hollow as much as 0.7 mm. diameter.

The spicules which lie in, or "core," the fibers are microspined oxeas, about 4 to 90 microns in dimensions. There are many smooth styles perpendicular both to the axial specialization and to the surface of the sponge, in plumose fashion, points out. These range from 6 × 185 microns as illustrated, up to 7 × 270 microns. There are also present thin tylostyles, often parallel to the axial specialization, their points towards the apices of the branches. These are typically 1 × 135 to 1.5 × 160 microns in dimensions.

This is the second species for the genus *Axechina*, which was established by Hentschel (1912: 417) for the species *raspailioides* from the East Indies. That and the present species agree in the raspailoid habitus, with an axial specialization of fibers cored with acanthoxeas, surrounded by radially placed smooth styles. Hentschel's species also had thin styles as long as 2200 microns, whereas the present sponge has instead the much smaller tylostyles. The East Indian sponge was strongly hispid, whereas the Hawaiian one is comparatively smooth; the specific name that is applied here is based on the Greek word for "smooth."

Eurypon distincta (Thiele) de Laubenfels

Sponges thus dubiously identified were dredged 14 February 1948 south of Diamond Head (Honolulu) at a depth of 75 meters, and 19 February 1948 south of Pearl Harbor, depth 50 meters. These were lipostomous crusts 100 to 300 microns thick, comparatively smooth, but microscopically hispid. This latter character results from a series of smooth tylostyles which generally are erect upon the substratum, points up. These spicules range from 10 to (generally) 17 microns thick, by 1000 or more microns long. Among them are numerous acanthostyles 6 × 75 to 8 × 60 microns in dimensions.

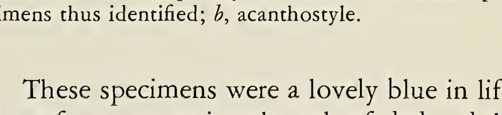

FIG. 5. Camera lucida drawing (× 635) of spicules of the sponge identified as *Eurypon distincta*: *a*, Head portion only of a tylostyle, showing the double-headed condition that frequently occurred in Hawaiian specimens thus identified; *b*, acanthostyle.

These specimens were a lovely blue in life, but after preservation the color faded and the sponges could not be found on the masses of coralline material upon which they grew. It had been intended to describe them as a new species, based on the color, but this now seems inappropriate.

Thiele (1903: 956) described a sponge as *Hymeraphia distincta* from the East Indies. This was transferred to *Eurypon* by de Laubenfels (1936: 110). Thiele does not cite the color in life, but the spicules of his *distincta* are similar to those of the Hawaiian sponges now being discussed.

There is a sound criticism for the dubious identification that is here made: it tends to indicate a faunal relationship between Hawaii and the East Indies that is not certainly valid. It is more likely that the vivid blue Hawaiian *Eurypon* specimens really do represent a distinctive species.

Microciona haematodes new species

This species was dredged 10 April 1949 near Kaena Point, Oahu, at a depth of more than 200 meters. It was growing on other sponges, of the genera *Stellettinopsis* and *Dorypleres* (q.v.). Quite likely it also grew on other substrates in the vicinity, but was not picked up by the dredge except on the more massive sponges. It was a persistently thin crust much less than a millimeter thick but spreading laterally indefinitely. A number of patches were visible, each about as large as a postage stamp, and nearly as thin. They were conspicuous because of their blood-red color. The name proposed here is derived from the Greek, meaning "blood stained." The specimens are to be deposited in the U. S. National Museum.

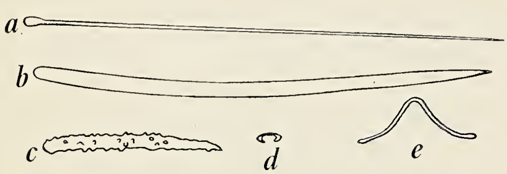

FIG. 6. Camera lucida drawing (× 635) of spicules of *Microciona haematodes*: *a*, Tylostyle; *b*, style; *c*, acanthostyle; *d*, isochela; *e*, toxa, perhaps foreign.

As is characteristic of such thin sponges, little can be said as to consistency, oscules, and pores. The skeleton is completely consistent with placement in the genus *Microciona*, and yet is remarkable. Typical members of this genus have a principal skeleton of smooth styles or subtylostyles arranged as fibers or tracts. The present species does contain a few, but only a few smooth styles, scattered and secondary. Typical *Microciona* has the tracts or fibers echinated by acanthostyles, which are generally scanty in numbers, even to the point of being difficult to find. The present species instead has principally acanthostyles of the echinating sort.

Comparison with the genus *Myxilla* is interesting. In that genus the spicules that apparently should be principal are rare, and the spiny echinating spicules abound. In *Myxilla* and in *haematodes* these acanthostyles form a distinctive isodictyal reticulation with many parallel spicules on each side of the triangular or polygonal meshes. This has been compared to a number of rooms built "log-cabin" style. In *Myxilla*, however, the dermal spicules are diactinal, whereas *haematodes* has monactinal ectospicules as in *Microciona*. The present species has palmate isochelas as typical of *Microciona*, but astonishingly almost or quite lacks the toxas that are present in nearly all species of *Microciona;* one was found, but was not certainly proper. Spicule dimensions are as follows: dermal tylostyles 2 × 200 to 4 × 400, generally 3 × 300 microns; smooth styles of the "coring" type 8 × 270 microns; acanthostyles 6 × 80 to 6 × 100 microns; palmate isochelas 15 microns long.

Microciona maunaloa de Laubenfels

This species has been reported (de Laubenfels 1951: 260) as occurring around the Island of Hawaii. A rather typical specimen was collected in Oahu 27 September 1947 in Waialua Bay at a depth between 4 and 8 meters. A *Microciona* collected 19 February 1948 south of Pearl Harbor may have been this species, but its toxas (?) were only oncebent instead of being the usual thrice-bent shape.

Ulosa rhoda new species

The type of this species was dredged 19 February 1948 at a depth of 50 meters, 3 kilometers south of Pearl Harbor. Another specimen was dredged 14 February 1948 at a depth of 20 meters, south of Diamond Head (Honolulu). The shape is cylindrical with, in each case, a single short branch. The diameter is about 2 cm. and the height about 8 cm. The consistency is spongy. The surface is coarsely cavernous, thus obscuring the pore-oscular situation. The caverns are about 1 mm. in diameter, representing the mesh of a fibro-reticulation of which the fiber ends often protrude from the surface. These fibers are 50 to 150 microns in diameter and contain many of the spicules, but there are also numerous spicules loose between the fibers. The spicules are all styles, varying generally from 13 × 400 to 15 × 310 microns; a few smaller ones are doubtless juveniles.

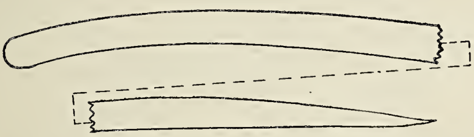

FIG. 7. Camera lucida drawing (× 635) of a typical spicule (Style) of *Ulosa rhoda*.

These sponges were particularly striking red in color when alive, and the name selected is based upon a Greek word for "rose." So far as is known, this color is unique in the genus.

Axinella solenoeides new species

This species was dredged 10 April 1949 at a depth of more than 200 meters, near Kaena Point. The specimens are to be deposited in the U. S. National Museum. It is a ramose sponge, with cylindrical branches 2 to 3 mm. in diameter, and up to 6 cm. high. The color in life was light red and the consistency flexible. The surface had the smoothness of velvet, and was lipostomous. As is typical of the genus *Axinella*, there is an axial specialization

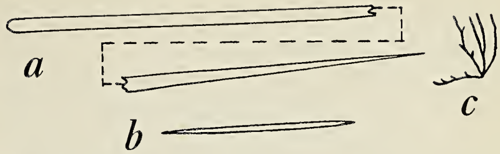

FIG. 8. Camera lucida drawing (× 635) of spicules of *Axinella solenoeides*: *a*, Style; *b*, oxea (Microxea); *c*, freehand sketch of the entire sponge, × 0.3.

comprising diactinal spicules, surrounded by outward-pointing monaxons. The axial specialization is generally a relatively solid core of fiber and spicule, and in places this is true of *solenoeides*, but in many places this sponge has an axial specialization that is a tube, with fibers and oxeote spicules around the hollow and parallel to it. The specific name is derived from a Greek word meaning "hollow," the distinctive characteristic of this new species. The oxeas vary from 1 × 60 to 3 × 90 microns; the styles of the plumose outer portion also vary considerably but are often about 4 × 160 microns in dimensions. The smaller oxeas may even constitute a category of raphides.

Homaxinella anamesa new species

This species was dredged 10 April 1949 at a depth of more than 200 meters, near Kaena Point. There were two separate collections; the type specimen is pronouncedly ramose with cylindrical branches 8 to 14, generally 10 mm. diameter. It reaches a height of 13 cm.

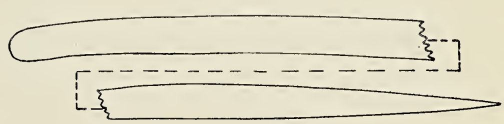

FIG. 9. Camera lucida drawing (× 635) of a typical spicule (Style) of *Homaxinella anamesa*.

The second specimen is somewhat flabellate due to lateral fusion of branches and is only about 7 cm. high. The color in life was bright vermillion red and the consistency spongy but easily torn. There was some obvious slime

production. The surface is conulose, with conules 1 mm. high and 2 to 3 mm. apart; between them are numerous apertures upwards of 1 mm. diameter and only 2 or 3 mm. apart on centers. Exhalant openings are not obviously differentiated from the inhalant ones. The skeleton consists of plumose tracts or fibers profusely echinated by smooth styles. This and the whole external appearance strongly resembles the *Homaxinella* (species *rudis*) that is so abundant in the Bermudas. That has styles 9 × 280 to 11 × 320 whereas the Hawaiian *Homaxinella* has styles 12 × 240 to 16 × 320 microns. The oscules are conspicuous in *rudis*. The other *Homaxinella* with the striking appearance of *rudis* and *anamesa* is *trachys* de Laubenfels (1954: 171) from Ebon, but its styles were much larger, 16×550 microns. The name *anamesa* is derived from a Greek adjective signifying "intermediate" or "in between." The specimens are to be deposited in the U. S. National Museum.

Densa distincta new species

This species was dredged 19 February 1948 at a depth of 50 meters, 3 kilometers south of Pearl Harbor. The specimen is to be deposited in the U. S. National Museum. It is an irregular mass, almost lobate, with projections about 3 or 4 mm. thick. The whole sponge is about 3 cm. diameter. The color in life was bright orange and the consistency dense, like cheese. The surface is smooth and lipostomous. The sponge is full of spicules in utter confusion. The majority are oxeas, but many are strongyles. The sizes range from 3 × 600 to 6 × 600 microns.

a

b

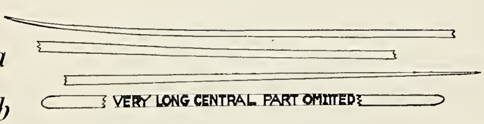

FIG. 10. Camera lucida drawing (× 635) of spicules of *Densa distincta*: *a*, A typical one of the oxeas, shown complete, but in three sections; *b*, the ends only of one of the strongyles, the long middle portion not shown.

This sponge answers to the definition of *Densa*, which is to say, *Hymeniacidon*-like, but with diactinal instead of monactinal spicules, but this is a heterogenous genus. The type, *Densa araminta* de Laubenfels (1934: 14), is a cavernous sponge with spicules of more commonplace proportions, whereas those of *distincta* are extraordinarily thin in proportion to their length. The other species that has been referred to this genus is *Densa mollis* de Laubenfels (1954: 191). It had small spicules and verged toward the genus *Collocalypta* by reason of mucous content, but *Collocalypta* has spongin fibers. Here is a genus of three species so diversified that their close relationship is questionable, yet they scarcely warrant erection of more new genera. The genus *Hymeniacidon*, which matches *Densa*, is similarly diversified and possibly polyphyletic.

Anthosigmella valentis new species

This species was dredged 10 April 1949 from a depth of more than 200 meters near Kaena Point. The specimen is to be deposited in the U. S. National Museum. It was a

a

b

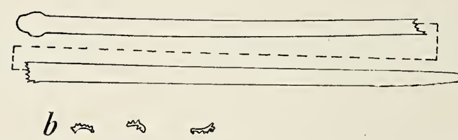

FIG. 11. Camera lucida drawing (× 635) of spicules of *Anthosigmella valentis*: *a*, Tylostyle; *b*, three of the distinctive microscleres.

massive, rounded sponge, 2 × 5 × 9 cm. in size, dark drab in color, cartilaginous in consistency but packed with coarse calcareous sand. The oscules and pores appear to have closed. The surface is smooth, the interior finely cavernous, and (as noted above) full of debris. The skeleton comprises stout smooth tylostyles 7 × 300 to 9 × 425 microns in dimensions, and peculiar spirasters 10 to (rarely) 14 microns in chord measurement. These are essentially sigmoid microstrongyles with a single row of tuberculate processes.

There are also present microscleres that are intermediate between typical spirasters and the peculiar forms.

There are two species already in *Anthosigmella*, each widely distributed. The first was described as *Thalysias varians* by Duchassaing and Michelotti (1864: 86), and was made the type of *Anthosigmella* by Topsent (1918: 557). This sponge is abundant throughout the West Indian region. The second species was described as *Spirastrella vagabunda* by Ridley (1884: 468). It is abundant throughout the Indian Ocean, East Indies, Philippines, and the islands of the West Central Pacific. In comparison to these, *valentis* is distinctive for its extensive content of sand. In its smallness of oscule it is more like *varians* than *vagabunda*, and its microsclere shape is more like that in *varians*, but the microsclere size is even smaller than in *vagabunda*, which in turn averages smaller than in *varians*. *Valentis* is a Latin word meaning "vigorous, valiant, healthy."

Prosuberites oleteira new species

This species was collected 29 March 1948 on the Naval dry dock at Pearl Harbor. It was placed so as to be generally two or more meters below the surface, but would occasionally be out of water entirely, as at the time of collection. It occurred in at least three different places on the dock. Another specimen was dredged 14 February 1948 from 18 meters depth, south of Diamond Head (Honolulu).

This is a paper-thin sponge, of a vivid dark yellow color, verging toward orange, smooth to the naked eye, lipostomous and softly colloidal. Extensive subdermal spaces are present. The skeleton consists of tylostyles with rather flat heads, many are about 7 × 230 microns in size, but there is variation; some are nearly twice that length. There is a tendency for these spicules to be placed erect, heads at the substrate and points up and out. The flesh is so thin, however, (50 to 150

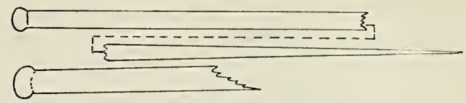

FIG. 12. Camera lucida drawing (× 635) of spicules of *Prosuberites oleteira*: *a*, Commonplace tylostyle; *b*, head only of a somewhat unusual sort that is common in this species.

microns only) that the longer spicules merely lie in confusion.

The type is to be deposited in the U. S. National Museum.

The genus *Prosuberites* is a puzzling one. Burton (1934: 316) would drop all of it, and all of *Protosuberites* in synonymy to *Suberites*, assuming that the former two consist only of juvenile *Suberites*. The typical *Prosuberites*, however, has spicules far larger than those of *Suberites*, and (more important) does not have special dermal smaller tylostyles. There is good evidence that some of *Prosuberites*, like the Hawaiian sponge now being discussed, persistently remain encrusting, growing only laterally once they are established.

As for *Protosuberites*, there are only two species firmly placed therein, each established by Swarchewsky (1905: 36), and neither one satisfactorily described. Neither they nor the characters of the genus are adequately known. It is probably a synonym, perhaps of *Pseudosuberites*, but now has uncertain status.

In *Prosuberites*, there are now three names, established for Japanese sponges by Thiele (1898: 40); these are *sagamensis*, *exiguus*, and *inconspicuus*. All three are described with excessive brevity and must be regarded as ill-known. There seems to be, however, no clear reason for differentiating them from one another, and all seem to be juvenile *Suberites;* all three are here regarded as being *Suberites sagamensis*. *Alcyonium epiphytum* Lamarck (1815: 163) is also here transferred to *Suberites*, being a juvenile.

In *Prosuberites* there are now six species with relatively huge spicules. These spicules, however, differ radically in proportions from one

species to another. The six species include the type, *P. longispina*, and *P. incrustans*, *mexicensis*, *perforatus*, *rugosus*, and *sisyrnus*.

In *Prosuberites* there are now three species with smaller spicules, only a little larger than those that are typical of *Suberites*, but not differentiated into categories as are those of *Suberites*. These three are *brevispinus*, *epiphytoides*, and *brondstedi*. To them should be added the similar species described as *Hymeraphia spinularia* by Bowerbank (1875: 282). *Protosuberites brevispinus* was described by de Laubenfels (1951: 215), but the author had no opportunity to correct proof. Thus it happened that by accident the spicule size was omitted from the original publication: it was 6 × 520 to 6 × 550 microns.

Prosuberites oleteira has spicules a little larger than those of the four species that are discussed in the preceding paragraph, but much smaller than the spicules of the more typical six. It has a lethal effect which is not recorded for any of the others, and which may be unique. On the other hand, this characteristic may be present in one or more of the *brevispinus* type, in which case some synonymization might later be in order.

It was clear that *oleteira* was destroying other sessile forms as it spread its thin growth outward. Some encrusting sponges grow into interstices, or are left in interstices; these latter spaces are angular, with rounded protrusions entering them. The growth of *oleteira* instead made rounded lethal encroachments over its neighbors, which were chiefly ascidians and annelids of the type that form small calcareous tubes. The name *oleteira* is derived from a Greek word meaning "murderess."

Stellettinopsis kaena new species

This species was dredged 10 April 1949 near Kaena Point, from a depth of more than 200 meters. Two separate specimens were collected, both to be deposited in the U. S. National Museum. Each is an irregular mass.

FIG. 13. Camera lucida drawing (× 635) of spicules of *Stellettinopsis kaena*: *a*, Central portion only of one of the oxeas to show its relative size; *b*, two of the sceptrelliform streptasters; *c*, two of the oxyeuasters.

That which is selected as type was 6 × 9 × 11 cm.; the other was 11 × 14 × 27 cm. The former was drab, darker at the surface than inside. The latter was so dark as to be nearly black. The consistency is cartilaginous and the surface is rough and lumpy. Both specimens contain foreign matter in scattered places, as though they had grown over neighboring organisms; this is not a case of incorporating foreign debris in proper skeletal structures. Both specimens were much overgrown as well. The type is nearly covered by patches of calcareous algae, the other specimen by a thin crust of *Microciona haematodes*. Both specimens are densely packed with large oxeas in confusion. These are somewhat larger in the type, ranging up to 36 × 2400 and 42 × 2000 microns in dimensions. In the other specimen sizes around 14 × 1000 microns are common. The microscleres include oxyeuasters 16 to (rarely) 20 microns in diameter, and streptasters uniformly about 12 microns in length. These show a pronounced tendency to have many spines arranged in two nodes that divide the spicule into equal thirds of length, no spines elsewhere except sometimes a few spines at the extreme ends.

Carter (1879: 349) described *Stellettinopsis simplex* from Australia. It has the sceptrelliform streptasters as in *kaena*, but they are 17 microns long, and are accompanied by diversified kinds of euasters. The other species which is most nearly like *kaena* was described from the Bermudas as *Stellettinopsis ketostea* (de Laubenfels, 1950: 112). The resemblance is indeed close, but *ketostea* had much larger euasters.

Dorypleres pleopora new species

The type of this species was dredged 19 February 1948 at a depth of 50 meters, 3 kilometers south of Pearl Harbor. A second specimen was dredged 10 April 1949 from a depth of more than 200 meters, near Kaena Point. The type specimen was a thin crust, but the second specimen was massive, 10×13 ×16 cm. in size. Each was bright lemon yellow and each darkened noticeably, to a sort of olive green or drab, after two or three weeks of preservation in alcohol. The consistency was cartilaginous. The surface was uneven, rough, but not especially hispid. No obviously exhalant openings were evident, but especially on the type specimen there were numerous scattered conspicuous pore sieves. In them the openings were 4×50 to 50×80 microns in size, and separated by narrow partitions only 40 microns thick. The ectosome contains more asters than the endosome; the latter is

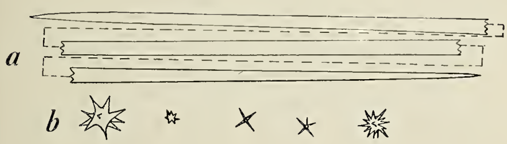

FIG. 14. Camera lucida drawing (× 635) of spicules of *Dorypleres pleopora*: *a*, One of the oxeas, shown complete, but in three sections; *b*, five of the asters.

packed with oxeas in confusion. These are 6×600, 8×600 to rarely 8×800 microns in dimensions in the type specimen, somewhat larger in the second specimen. The asters are of two distinct sorts. There are spherasters with many smooth, sharp rays, diameters 7 to 20 microns, with all intermediate sizes. There are also oxyeuasters regularly 10 microns in diameter, with few, often only 6 or 8 rays. The type is to be deposited in the U. S. National Museum.

The pore areas suggest those of the sponge described by Dendy (1916: 247) as *Aurora cribriporosa*, but that sponge had radiate symmetry and a thick cortex, two sizes of oxeas (one huge) and much larger asters. It never belonged in *Aurora*, which is a choristid genus; nevertheless *Aurora* needs attention because the name was preoccupied in 1887 by Ragonot for Lepidoptera, hence the following action is taken here:

Aurorella (new name) is here proposed for *Aurora* Sollas (1888: 187). The genotype is *Stelletta globostellata* Carter (1883: 353).

The above-mentioned *cribriporosa* has been put in *Rhabdastrella*, and so has *Diastra sterrastraea*, the genotype of *Diastra* Row (1911: 301). Because of its sterrasters, it is here proposed that *Diastra* be restored to full and valid generic standing. On the other hand, *Rhabdastrella* Thiele (1903: 934) is in no significant way different from *Dorypleres* Sollas (1888: 426), and should be dropped in synonymy to *Dorypleres*. Within this genus the other species closest to *pleopora* is *splendens* de Laubenfels (1954: 226) from Ponapé. These two species have oxeas much smaller than those of the other species of the genus, and little or no radiate structure; they conceivably might be given separate generic standing. *Dorypleres splendens* was bright orange, and its microscleres were spined; furthermore, it did not have obvious pore-sieves.

Erylus rotundus Lendenfeld

This species was dredged 19 February 1948 at a depth of 50 meters, 3 kilometers south

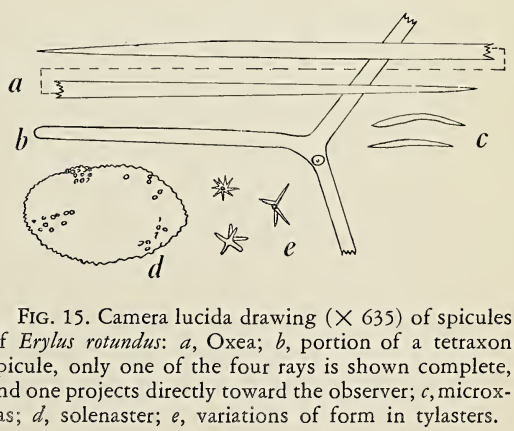

FIG. 15. Camera lucida drawing (× 635) of spicules of *Erylus rotundus*: *a*, Oxea; *b*, portion of a tetraxon spicule, only one of the four rays is shown complete, and one projects directly toward the observer; *c*, microxeas; *d*, solenaster; *e*, variations of form in tylasters.

of Pearl Harbor. There were two subspherical specimens, human fist size, nearly black exteriorly but drab as to interior. The consistency was cartilaginous. The oscules were about 1.5 mm. in diameter. The surface revealed numerous pores 70 to 140 microns in diameter. The ectosome is a cortex 100 microns and more in thickness. The endosome is vaguely radiate in architecture. The spicules are principally smooth oxeas, about 9×500 microns, but there are scattered tetraxons with rays about 7×140 microns. There are four kinds of microsclere. There are microxeas about 3×50 microns, often bent, indicating that they may represent large asters with rays reduced in number to two. There are microtuberculate chiasters or tylasters about 17 microns in diameter, with few rays, and others only 12 microns in diameter with many rays. Finally there are the peculiar aspidasters that characterize the genus *Erylus*. They are oval plates 3 microns thick and about 50×85 microns in surface size, completely covered with tubercles about 2 microns high and 2 microns in diameter. These plate-or-scale like spicules constitute a sort of dermal armour. They develop from asters, all of whose rays lie in a single plane.

In 1904 and 1905 Alexander Agassiz, aboard the U. S. Fish Commission Steamer "Albatross," collected in the Eastern Tropical Pacific. The vast numbers of sponges thus acquired are presumably in the collections of Harvard University at Cambridge, or in the U. S. National Museum. They were, almost immediately, made available for study by R. von Lendenfeld. In 1910 he published in the memoirs of the Museum of Comparative Zoology of Harvard a huge quarto volume on the family "Geodidae" (it should be Geodiidae) and another nearly as large on the family "Erylidae." In 1915 a massive two volume work appeared on the Hyalospongea thus collected. The volume on Geodiidae concerns only one certain genus, and scarcely a dozen valid species, which could be thoroughly described in 20 or 30 pages. The volume on Erylidae concerns less than half a dozen certain species, which could be appropriately described and discussed in about a dozen such large pages. The volumes in question are masterpieces of verbosity.

The scientists who travelled on the "Albatross" found no hyalosponges near Hawaii, nor any *Geodias*, but did find an *Erylus*. As was his custom, Lendenfeld made three species and two additional subspecies for it. Using his criteria, the specimen described above would be yet another species, and the next one collected in the future would be yet another. Lendenfeld used the names *rotundus*, *caliculatus*, and *sollasii;* the latter two of these names are here dropped in synonymy to *rotundus* (page 290), with some misgivings that all may possibly be synonyms of *Erylus nobilis* Thiele (1900: 48). Lendenfeld records his *Erylus caliculatus* from north of the Island of Hawaii, *Erylus sollasii* from south of Molokai, his *Erylus rotundus* from near Hawaii, and also from Hawaii and Molokai.

(?) **Leucosolenia vesicula** (Haeckel) Dendy and Row

Haeckel (1872: 41) described a remarkable sort of sponge, calling it first *Ascetta vesicula*, then later calling it *Clistolynthus vesicula*. He states that he found four specimens of it on floating Sargasso-weed, collected by Captain Halterman in the neighborhood of Honolulu. The weed was densely covered with hydroids and bryozoans. All four examples of *vesicula* were hollow balls with no trace of an oscule, total size 2 to 3 mm. in diameter. The only spicules present were sagittal triaxons with rays 10×80 to 12×90 microns in dimensions. It seems highly probable that these were immediate post-fixation stages of some sponge that may have appeared quite different when adult–this could even have been a juvenile *Leuconia* or (more likely) a *Leucetta*.

FRESHWATER SPONGES OF OAHU

In April 1941 Professor Arthur Svihla of the University of Washington sent the author

a manuscript describing freshwater sponges that he had personally found at Haepuaena on the Hawaiian Island of Maui and that Otto Degener had found on Oahu. Professor Svihla identified these as *Heteromeyenia baileyii* new subspecies. The present author concluded from the excellent descriptions rendered that they were typical *baileyii*, not a new variety. Therefore Professor Svihla so published them in a short article in SCIENCE.

Otto Degener and the present author repeatedly collected freshwater sponges on Oahu. They are common in the streams on the west or leeward side of the Koolau Mountains. These sponges look very much like *Heteromeyenia*, and closely resemble *H. baileyii* in particular. A perplexing difficulty, however, arises.

The genus *Heteromeyenia* is set off from the otherwise similar genus *Meyenia* by a difference in the special gemmule spicules. In *Meyenia* these are birotulate or amphidisc microscleres all of a single category. In *Heteromeyenia* there are similar amphidiscs, but also a second category of much longer, attenuated amphidiscs occurs among them.

The present author collected many specimens from various Oahu locations, and from each many gemmules. Numerous microscopic preparations were made, and studied for many hours. He was never able to find a single example of the second type of microscleres; every one of the specimens keyed to *Meyenia*, not to *Heteromeyenia*.

The Oahu specimens do not match any of the species that have been described in the genus *Meyenia*. They do fit perfectly the species *baileyii* of *Heteromeyenia* in every respect except the one that is used to separate that genus from *Meyenia*. The opinion is here expressed that they are indeed *baileyii*, but that those in Oahu have a most perplexing rarity of a critical characteristic. It would be interesting if the Oahu freshwater sponges were examined on successive years, and at various times per year; perhaps there is a time when the *Heteromeyenia* characteristic appears.

DISTRIBUTIONAL NOTES

Waialua Bay was studied 27 September 1947, chiefly by face-plate diving. The following sponges were found: *Spongia oceania*, *Haliclona permollis* (?), *Xytopsiphum kaneohe*, *Callyspongia diffusa* (?), *Toxadocia violacea*, *Microciona maunaloa*, *Terpios zeteki*, *Cliona vastifica*, *Zaplethes digonoxea*, and *Leucetta solida*.

On 18 October 1947 a study was made of a large, shallow, nearly enclosed area known as the West Loch of Pearl Harbor, in a part of it called Ulumoku Pond. Sponges were abundantly present. Two or three of these proved to be *Mycale cecila* but all of the many others were *Terpios zeteki*.

On 10 December 1947 an intensive study was made of the pilings in various portions of Honolulu Harbor. One interesting observation concerned the fact that where wastes from the pineapple canneries entered the harbor there were no sponges, and few other sessile invertebrates were present. The commonest animals on the pilings seemed to be: Finger-sized grey ascidians, annelids with calcareous tubes, erect bryozoa (*Bugula*?), bivalve mollusks (*Anomia* and *Ostrea*?), barnacles (*Balanus amphitrite*?), and, on nearly every piling, the sponge, *Mycale cecilia*.

On the 24th, 25th, and 26th of January 1948 an especially severe storm struck Oahu. On January 28th the beaches were studied from the southeast tip to the northwest side, for the wrack that is cast up by the waves. The only sponges found there were *Spongia oceania*. It seems to be commoner, and to grow larger, than any other Hawaiian sponge. The natives called sponges "upi," from their word for "to squeeze," also "hu'e hu'e kai," which means "foam of the sea."

On 14 February 1948 study was made both by diving and dredging near Koko Head (near Hanauma Bay). Vernon Brock, who was the most expert diver, reported that the bottom was liberally sprinkled with specimens that were obviously *Spongia oceania*. Others found included: *Xytopsues zukerani*, *Tedania ignis*,

Lissodendoryx calypta, *Axechina lissa*, *Eurypon distincta*, *Microciona maunaloa*, *Prosuberites oleteira*, *Ulosa rhoda*, and *Leucosoleonia eleanor*.

On 19 February 1948 dredging was carried on 2 to 3 kilometers south of Pearl Harbor. The following eleven sponge species were thus collected: *Hexadella pleochromata*, *Haliclona flabellodigitata*, *Tedania ignis*, *Lissodendoryx calypta*, *Eurypon distincta*, *Microciona maunaloa*, *Ulosa rhoda*, *Densa distincta*, *Dorypleres pleopora*, *Erylus rotundus*, and *Leucetta solida*.

This is an astonishingly great variety of Porifera to be found in such a limited area with but the one method of collecting.

On 11 March 1948 a study was made of barges that had been in Pearl Harbor for three years continuously, but on that day were finally put in dry dock for cleansing of their extremely foul bottoms. A barge that had been long at Kwajalein in the Marshall Islands, and then for three months at Pearl Harbor, was studied at the same time. The latter differed in sponge fauna from the former in having specimens of *Tethya*, and in lacking calcisponges. Six species occurred on both. This boat-bottom sponge fauna included: *Haliclona permollis* (?), *Pellina sitiens*, *Mycale cecilia*, *Prosuberites oleteira*, *Zygomycale parishii*, *Terpios zeteki*, *Tethya diploderma*, and *Leuconia kaiana*.

On 29 March 1948 another batch of ship bottoms was examined in dry dock; they revealed chiefly *Pellina*, *Mycale*, *Prosuberites*, and *Zygomycale*.

On 15 April 1948 still another batch of ship bottoms was examined in dry dock; these revealed *Mycale*, *Terpios* and *Zygomycale*.

On 10 April 1949 sponges were dredged near Kaena Point, at a depth of more than 200 meters. This collection included: *Microciona haematodes*, *Axinella solenoides*, *Homaxinella anamesa*, *Anthosigmella valentis*, *Stellettinopsis kaena*, and *Dorypleres pleopora*.

These are all new species, and the assortment is strikingly different from that of shallow water Oahu.

FAUNAL RELATIONSHIPS

The Hawaiian Islands are so isolated that, as may be expected, their shallow-water invertebrate fauna is largely endemic. This is emphatically true for the sponge fauna of Oahu, as outlined above. A minority of Hawaiian sponges show relationships to species from other parts of the world; these warrant further notice.

One Hawaiian sponge has been identified as being *Pellina sitiens*, properly a North Atlantic species. This identification is dubious, in that a new name may be needed for the Hawaiian *Pellina*, but some relationship is clearly indicated. On the other hand, *P. sitiens* may prove to be circumequatorial.

Oahu sponges have been identified with the following circumequatorial species: *Dysidea avara*, *Haliclona permollis*, *Myxilla rosacea*, *Tedania ignis*, *Zygomycale parishii*, *Cliona vastifica*, *Tethya diploderma*, *Plakortis simplex*, and *Leucetta solida*.

Five sponge species from Oahu have been identified with species that are not known to be circumequatorial, and which do occur to the west of the Hawaiian Islands. These are: *Haliclona flabellodigitata* (Australia), *Callyspongia diffusa* (Indian Ocean, East Indies, Micronesia), *Oscarella tenuis* (Australia), *Lissodendoryx calypta* (Eniwetok), and *Eurypon distincta* (East Indies).

It is worthy of notice that each of these five identifications is merely tentative and is certainly questionable. Each of the five may require a new name, indicating an endemic nature.

Five sponge species from Oahu have been identified with species that are not known to be circumequatorial, and which do occur to the east of the Hawaiian Islands. These are: *Adocia gellindra*, *Toxadocia violacea*, *Mycale cecilia*, *Terpios zeteki*, and *Leucosolenia eleanor*.

The opinion is here expressed that these identifications are more nearly certain, more dependable, than the preceding five identifications.

Ekman in his "Zoogeography of the Sea," page 19 and following, summarizes faunal relationships for the Hawaiian Islands as embodied in the literature. He had no data for the Porifera, but had ample data for most of the other great divisions of the animal kingdom. He reveals a pattern of great resemblance between the marine invertebrate faunas of Hawaii on the one hand, and those of the Asiatic-Australian-East Indian regions on the other hand. The fish faunas show this resemblance to an even greater degree. Other sources point to great resemblances between the floras of Hawaii and Asia.

Endemic species are rather more prominent in the Hawaiian sponge fauna than in faunas of other animal (and plant) groups. The few exotic sponge species show astonishingly little relationships to faunas of Asia, Australia and the East Indies. Relationship between Hawaiian sponges and those of the Pacific Coast of the Americas is not great, yet it is the most nearly worthy of attention as indicating zoogeographic affinity.

Could this American relationship be due to transport of sponges on ship bottoms? Sponges occur fairly commonly among the fouling organisms. With the possibility of transport in mind, studies were made of the bottoms of vessels in dry dock at Pearl Harbor. The results were inconclusive, but not negative. It seems clear that on a long ocean voyage most of the sponges on the ship's bottom perish, but a few might possibly survive.

TAXONOMIC NOTES

An important genus of Porifera has been known by the name of *Heteronema*, a name established by Keller (1889: 339). This name is even used in the author's 1946 monograph of the order Keratosa. It should not have been used, however, because it was preoccupied in 1841 by Dujardin for a protozoan.

The genus in question is characterized as resembling *Spongia*, but having foreign debris in the secondary fibers as well as in the primary fibers. This also was the diagnosis given by Lendenfeld (1885: 543), to his then new subgenus *Silicifibris* of the genus *Spongia*, hence this *Silicifibris* warrants attention.

The first species assigned to *Silicifibris* was the new species *galea*, here designated as the genotype. It was based on a macerated skeleton of a vase-shaped sponge, 25 cm. in diameter and height, with a sharp edged rim. This shape, and all details of the skeleton as described, match the long-established genus *Phyllospongia*.

The second species assigned to *Silicifibris* was Ridley's *Euspongia foliacea*. In a personal communication, Dr. Maurice Burton of the British Museum states that *foliacea* is a synonym of Carter's *Coscinoderma lanuginosum*, which has been transferred to *Phyllospongia*.

The third and last species assigned to *Silicifibris* was *silicata*, new, which may have been a *Dysidea*. The subgenus (or genus) *Silicifibris* should be regarded as a synonym of *Phyllospongia*. A new name is therefore required for the genus *Heteronema* as above described: ***Inodes***, new name for *Heteronema* Keller (1889: 339).

Genotype: *Heteronema erecta* Keller 1889, page 339. Sponges of the family Spongiidae, with all the fibers, both primary and secondary, containing much foreign debris. The name is based on a Greek word meaning "fibrous."

Two other similar corrections require attention. In a paper by de Laubenfels (1955) the generic names *Walcottella* and *Waagenella* are established. The first of these was preoccupied by Ulrich and Bassler in 1931, for a crustacean. The second was preoccupied by Koninck in 1883, for a mollusk. New names are therefore required, as follows: ***Walcottium*** new name for *Walcottella* de Laubenfels (1955: 82). Genotype *Scyphia pertusa* Goldfuss 1833. ***Waagenium*** new name for *Waagenella* de Laubenfels (1955: 102). Genotype *Steinmannia salinaria* Waagen and Wentzel (1888: 979).

REFERENCES

BAAR, R. 1903. Hornschwämme aus dem Pacific. *Zool. Jahrb., Abt. f. System.* 19: 27–36.

BOWERBANK, J. S. 1875. Contributions to a General History of the Spondiadae. *Zool. Soc. London, Proc.* Pp. 281–296.

BURTON, M. 1934. Sponges (Great Barrier Reef Expedition 1928–29 Scientific Reports). *Brit. Mus. Nat. Hist.* 14: 513–614, pls. 1–11.

——— 1934. Observations on Post-larval Sponges of the Genus *Suberites*. *Ann. and Mag. Nat. Hist.* Ser. 10, 13: 312–317.

CARTER, H. J. 1879. Contributions to our Knowledge of the Spongida. *Ann. and Mag. Nat. Hist.* Ser. 5, 3: 343–360.

——— 1883. Contributions to our Knowledge of the Spongida. *Ann. and Mag. Nat. Hist.* Ser. 5, 11: 344–369, pls. 14, 15.

DE LAUBENFELS, M. W. 1934. New Sponges from the Puerto Rican Deep. *Smithsonian Inst., Misc. Collect.* 91(17): 1–28.

——— 1936. A Discussion of the Sponge Fauna of the Dry Tortugas in Particular and the West Indies in General, with Material for a Revision of the Families and Orders of the Porifera. *Carnegie Inst. Wash., Pub.* 467: 1–225, pls. 1–22.

——— 1950. The Sponges of Kaneohe Bay, Oahu. *Pacific Sci.* 4(1): 3–36.

——— 1950. The Porifera of the Bermuda Archipelago. *Zool. Soc. London, Trans.* 27 part 1: 1–154, pls. 1, 2.

——— 1951. The Sponges of the Island of Hawaii. *Pacific Sci.* 5(3): 256–271.

——— 1951. A Collection of Sponges from the Black Sea. *Arch. f. Hydrobiol. u. Planktonkunde* XLV: 213–216

——— 1954*a*. Occurrence of Sponges in an Aquarium. *Pacific Sci.* 8(3): 337–340.

——— 1954*b*. *The Sponges of the West-Central Pacific*. 306 pp., 12 pls. Oregon State College, Corvallis, Oregon.

——— 1955. *Treatise on Invertebrate Paleontology. Porifera.* Vol. E: 21–122. Lawrence, Kansas.

DENDY, A. 1916. Report on the Homosclerophora and Astrotetraxonida collected by H.M.S. "Sealark" in the Indian Ocean. *Linn. Soc. London, Trans.* 17 part 2: 225–271, pls. 44–48.

DUCHASSAING DE FONBRESSIN, P., and G. MICHELOTTI. 1864. Spongiaires de la Mer Caraibe, Memoire public par la Societe hollandaise des sciences a Harlem. *Natuurk. Verhandel. Mijnbouwk. Haarlem* 21: 1–124, pls. 1–25.

EDMONDSON, C. H. 1946. Reproduction in *Donatia deformis* (Thiele). *Bernice P. Bishop Mus., Occas. Paper* 18(18): 271–282.

GEORGE, W. C., and H. V. WILSON. 1919. Sponges of Beaufort (N. C.) Harbour and Vicinity. *U. S. Bur. Fisheries, Bul.* 36: 129–279.

HAECKEL, E. 1872. *Die Kalkschwämme: eine Monographie. System der Kalkschwämme.* Vol. 2, pp. 1–148. Berlin.

HENTSCHEL, E. 1912. Kiesel-und Hornschwämme der Aru-und Kei-inseln. *Naturf. Senckenb. Gesell. Abhandl.* 34: 295–448, pls. 13–21.

KELLER, C. 1889. Die Spongienfauna des rothen Meeres (I. Halfte). *Ztschr. f. Wiss. Zool.* XLVIII: 311–405, pls. 20–25.

LAMARCK, J. P. B. P. A. DE MONET. 1815. Suite des Polypiers empatés (dont l'exposition commence au 20 e Vol. des Annales, p. 294). *Mem. du Muséum* 1: 162–168.

LENDENFELD, R. VON. 1885. A Monograph of the Australian Sponges. Part 6. *Linn. Soc. N. S. Wales, Proc.* 10: 481–553.

——— 1910. The Sponges, 2. The Erylidae. *Harvard Univ. Mus. Compar. Zool., Mem.* XLI(2): 267–323, pls. 1–8.

RIDLEY, S. O. 1884. Spongida. IN *Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert" 1881–1882.* Pp. 366–482, 582–630, pls. 39–43, 53–54. British Museum (Natural History), London.

ROW, R. W. H. 1911. Report on the Sponges

Collected by Mr. Cyril Crossland in 1904–5. Part II, Non-Calcarea. 19th Rep. of Rep. Marine Biol. Sudanese Red Sea. *Linn. Soc. London, Jour.* 31: 287–400, pls. 35–41.

SCHMIDT, O. 1870. *Grundzüge einer Spongien-Fauna des Atlantischen Gebietes.* Pp. 1–3, pls. 1–6. Leipzig.

SOLLAS, W. J. 1888. *Report on the Tetractinellida Collected by H.M.S. "Challenger," during the years 1873–1876. Zool.* 25: 1–458, pls. 1–44.

SVIHLA, A. 1941. Report on Freshwater Sponges. *Science.* September 1941. P. 278.

SWARCHEWSKY, B. (Beitrag zur Kenntniss der Schwamm-Fauna des Schwartzen Meeres) in Russian, with German Abstract. *Soc. Nat. Kiew, Mem.* 20: 1–59, pls. 1–7.

THIELE, J. 1898. Studien uber pazifische Spongien. *Zoologica* 24: 1–72, pls. 1–8.

——— 1900. Kieselschwämme von Ternate. *Senckenb. Naturf. Gesell., Abhandl.* 25: 19–80, pls. 2, 3.

——— 1903. Kieselschwämme von Ternate. *Senckenb. Naturf. Gesell., Abhandl.* 25: 933–968, pl. 28.

TOPSENT, E. 1918. Éponges de San Thomé. Essai sur les generes *Spirastrella, Donatia et Chondrilla. Arch. de Zool. Expt. et Gén.* 57: 535–618. Paris.

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——— 1920*b.* Cerotrioza (Psyllidae, Homoptera). *Hawaii. Ent. Soc., Proc.* 4 (2): 374–375.

ROCK, JOSEPH F. 1916. The sandalwoods of Hawaii; a revision of the Hawaiian species of the genus *Santalum. Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry Bot., Bul.* 3: 1–43, 13 pls.

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VOL. XI JULY 1957 NO. 3

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

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The Chaetognath Fauna off Peru in 1941[1]

Robert Bieri[2]

El Niño and the "Callao painter" of the Peruvian Coast have attained a classic stature in the annals of oceanography. The catastrophic effect of this phenomenon on the marine life of Peru is well known. The less devastating El Aguaje (literally strong current or rising tide) is not as notorious, but is nevertheless of considerable interest because it is a more general phenomenon, occurring off California, west Africa, and elsewhere.

Following the terminology of Sverdrup, Johnson, and Fleming (1942), El Niño is used in this paper to designate the intrusion south along the Peru coast of warm water less saline than the general surface water of the Peru current. In years of unusually heavy penetration of this water to the south the rainfall on the normally dry Peruvian coast is very great. El Aguaje refers to the intrusion to the coast of warm, relatively more saline water of oceanic origin from the west. This is frequently accompanied by minor red tides but does not bring heavy rainfall as does El Niño.

Such phenomena are not only of great economic importance due to the destruction of marine life, but also are of considerable scientific interest because they transport pelagic communities great distances from their normal ranges. Despite this, the precise effects of such occurrences on the quality and quantity of the local fauna are very poorly known.

The following discussion describes in some detail the distribution of 15 species of Chaetognatha in the surface water of the Peru coastal current in 1941, in the hope that it will serve as a basis for comparison with future work in the region and will allow a better evaluation of the effects of these disturbances on the local fauna.

ACKNOWLEDGMENTS

It is a pleasure to thank Dr. Thomas E. Bowman of the United States National Museum for bringing the existence of the 1941 samples to the attention of the author and for his help in collecting data concerning the net tows. The samples were examined at the National Museum and the use of its facilities and equipment is gratefully acknowledged. Thanks are also due the Scripps Institution of Oceanography for the use of its facilities in examining the 1952 Shellback Expedition samples. Preparation of the manuscript for publication and examination of the National Museum material was partially supported by a Rockefeller Foundation Grant (RF 54087) to Lamont Geological Observatory, Columbia University.

PREVIOUS WORK

Our meager knowledge of the Chaetognatha in the southeast Pacific comes from a report by Baldasseroni (1915) who listed three species, *Sagitta enflata*, *S. lyra*, and *S. serratodentata* from a single station off Chile. The reports of Grey (1931) and Rose (1953) give some idea of the fauna far to the west in the central south Pacific.

The physical characteristics of the region are known chiefly from papers by Schott (1931), Gunther (1935), and a review of these and other data by Sverdrup, *et al.* (1942). Schweigger (1940) describes some of the physical and biological features present off the Peru coast in 1939. Sears (1954) gives an extensive list of literature dealing with the Peruvian coastal region. Fleming (1940), Schaefer (1954), Bowman (1955), Juhl (1955),

[1] Contribution from the Lamont Geological Observatory, No. 243, Biology Program 8. Manuscript received April 23, 1956.

[2] Lamont Geological Observatory, Columbia University, Palisades, New York.

Wilson and Shimada (1955), and Wooster and Jennings (1955) discuss various aspects of the hydrography and biology of the eastern tropical Pacific.

Several collections of zooplankton have been made in the vicinity of Peru—among them the Albatross, Dana, Discovery, and Carnegie collections—but analyses of the chaetognaths from these have not been published. During the course of a United States fisheries mission to Peru in 1941, Mr. Milton J. Lobell collected 25 plankton samples between Callao and the Gulf of Guayquil in the period May 6 to 9 (Fig. 1). These samples form the basis of this report.

Recently zooplankton collections have been made off Peru by Scripps Institution in 1952 and 1955, and by the California Division of Fish and Game and the Bingham Oceanographic Laboratories in 1953 (Posner, 1954). The results of the plankton investigations of these institutions are not yet published, but the chaetognaths from the collections of the Scripps Shellback Expedition in 1952 (240 samples), and of the California Department of Fish and Game Longline Expedition in 1953 (26 samples), have been examined by the author. Part of the extensive 1952 material, in preparation for publication, is compared with the 1941 collection.

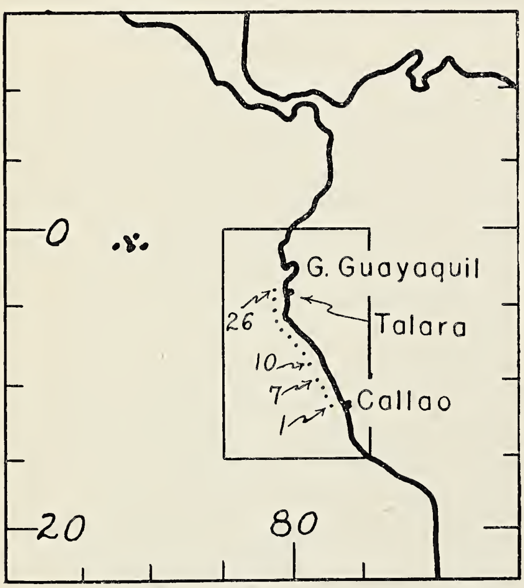


FIG. 1. Location of 1941 plankton samples. Every other station shown. Sample from station 9 not included in this report.

METHODS

The 1941 samples, preserved in dilute formalin, were collected with a one-half meter net made of bobbinet. The exact mesh of the bobbinet is not known, but judging from the size of the specimens caught it appears that the mesh was within the range of one-half to three-quarters of a millimeter. All of the tows were made at the surface and were of five minutes duration. Because of the uncertainty of the mesh size and the unknown speed of towing, no attempt has been made to estimate the volume of water filtered by the net. Instead the total number of specimens of each species collected in the tow is reported.

The author has found the following papers helpful in identifying the chaetognath species: Michael (1911), Ritter-Zahony (1911), Tokioka (1939 and 1940), Daken and Colefax (1940), Thomson (1947), and Fraser (1952). The nomenclature of Furnestin (1953), has been used for part of the *S. serratodentata* group.

RESULTS

Fifteen species of Chaetognatha were found in the surface waters off the Peruvian coast in 1941. Eight, or more than one-half of these, indicate warmer water present in May 1941 than in August 1952. Of the eight species, five, *Sagitta bedoti*, *Sagitta californica*, *Sagitta ferox*, *Sagitta neglecta*, and *Sagitta tenuis*, invaded the Peru coastal waters from the north. Three species, *Krohnitta pacifica*, *Sagitta regularis*, and *Sagitta robusta* penetrated the coastal waters from the west or the north. The remaining seven species, *Pterosagitta draco*, *Sagitta enflata*, *Sagitta hexaptera*, *Sagitta lyra*, *Sagitta minima*, *Sagitta pacifica*, and *Sagitta* sp., probably would show marked differences between May 1941 and August 1952 if it were possible

to compare their relative abundances or absolute concentrations.

In Figure 2 the total number of chaetognaths found at each station is shown. At no station were chaetognaths absent, but at the southernmost station only a single specimen was taken. The data are highly variable and no general trend is evident. The day tows averaged four times as many chaetognaths as the night tows but because of the great variability in abundance this is not regarded as significant.

In Figure 3 the number of species found at each station is shown. Although the data are highly variable, a general decrease in the number of species at the southern stations is apparent. This is due to a lack of equatorial and central oceanic species at the southern stations.

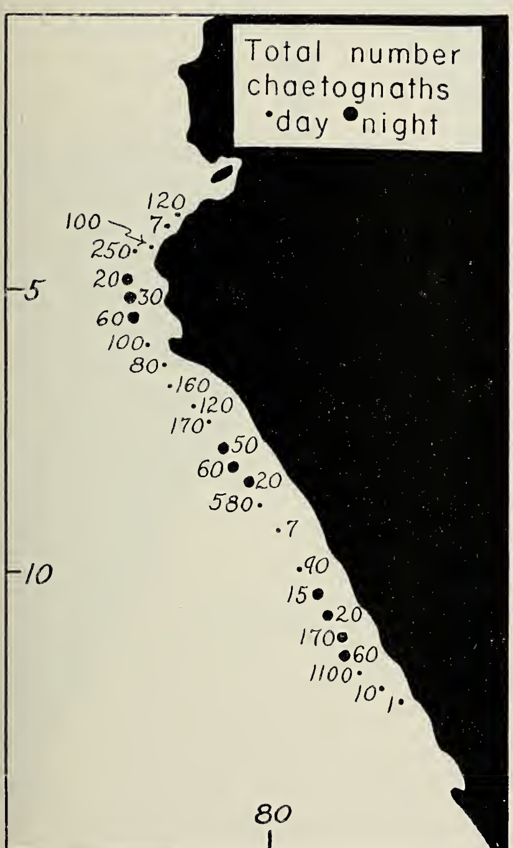


FIG. 2. Number of chaetognaths taken at each station in May 1941.

FIG. 3. Number of chaetognath species found at each station in 1941.

Pterosagitta draco (Fig. 4),* occurred at all but four stations. This species, which can be characterized as a warm water inhabitant, is found throughout the Pacific except off the California and Korean coasts between roughly 40 degrees north and 40 degrees south (Bieri, unpublished data). As might be expected, it does not show any marked discontinuities in the Peru region, but does appear to decrease in abundance at the southern stations.

Krohnitta pacifica (Fig. 5) occurred at nine nearly consecutive stations. This species was absent from the inshore stations off Peru during August, 1952 (Shellback Expedition).

* In Figures 4–13, the numbers refer to the number of specimens of the chaetognath species being discussed which were taken in a five-minute surface tow, using a one-half meter net.

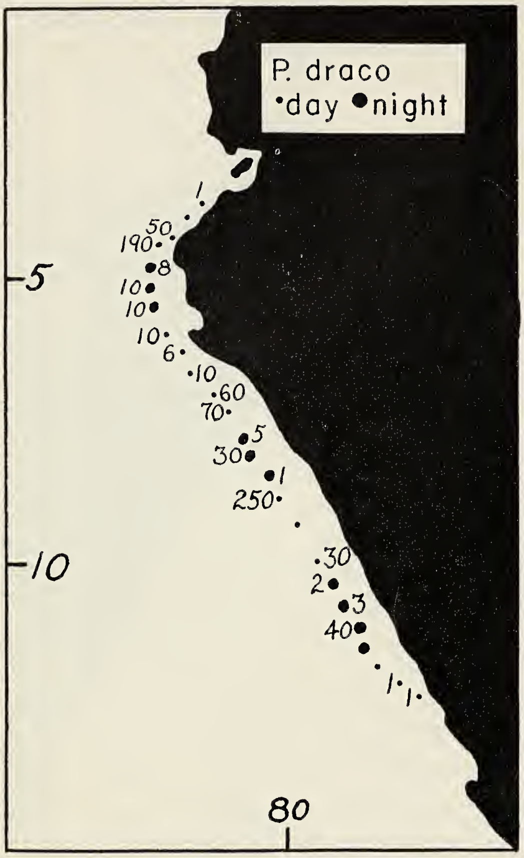


FIG. 4. Occurrence of *Pterosagitta draco* off Peru in 1941. (Number per five-minute surface tow, one-half meter net.)

Whether or not this difference is a seasonal one can only be shown by repeated short interval sampling over a period of several years. It can be said, however, that the presence of the species closer to the coast in 1941 could be due to greater penetration of south Pacific central water from the west towards the coast in 1941 or greater southern penetration of equatorial water from the north.

Sagitta bedoti occurred sporadically in low numbers at 14 stations (Fig. 6) with the greatest numbers in the north. It was found in the nearshore region of Peru in 1952 but appears to have penetrated further south in 1941.

Immature specimens of what appeared to be *Sagitta californica* were found at four stations (a single specimen at stations 14, 18, and 9 and three specimens at station 17). This species is widespread in the Pacific, occurring from roughly 38 degrees north to 38 degrees south; however, it is missing or extremely rare in the equatorial region (about 5 degrees north to 5 degrees south) and is missing from most of the California current. It is not common near shore except during unusual conditions such as reported by Michael in 1913. It was present at only one station off Peru in 1952 (14°01′S, 81°47′W) but was common north of the equator at that time. It appears most likely that the specimens in 1941 came from the north although the possibility of an intrusion from the southwest of Peru cannot be definitely ruled out.

Sagitta enflata (Fig. 7) occurred at all but three of the 1941 stations. Its distribution in

FIG. 5. 1941 distribution of *Krohnitta pacifica* compared to 1952. Crosses with hatchure—present 1952, without hatchure—absent 1952.

Fig. 6. Distribution of *Sagitta bedoti* in 1941 and 1952. Crosses with hatchure—present 1952, without hatchure—absent 1952.

the Pacific is very similar to that of *P. draco* and does not indicate any major change. A large form of *S. enflata* maturing at 20 mm. or longer was taken at stations 2, 3, 4, 19, and 21. In 1952 this form was also recorded from the Peru current.

The distribution of *Sagitta ferox* (Fig. 8), except for its occurrence at station three, is very similar to that of *K. pacifica* and suggests a common origin of the two local populations. In 1952 it was missing south of the equator except for four stations west of 100 degrees west longitude. Thus it would appear that this species could only have come from the north.

Sagitta hexaptera (Fig. 9) was found in small numbers at 12 stations in 1941. Its distribution throughout the Pacific is similar to but somewhat more widespread than that of *P. draco* and *S. enflata*; however, it is not usually found as close to shore as *S. enflata* nor is it as abundant. This together with its possibly different vertical distribution probably explains its patchy appearance in the 1941 collections.

Single specimens of *Sagitta lyra* were taken at stations 22, 17, and 14 and ten specimens at station 23. This species is found throughout the Pacific from approximately 45 degrees north to about 45 degrees south latitude. It is usually absent from very warm surface waters, inhabiting the cooler waters below. Its occurrence at the above stations therefore might

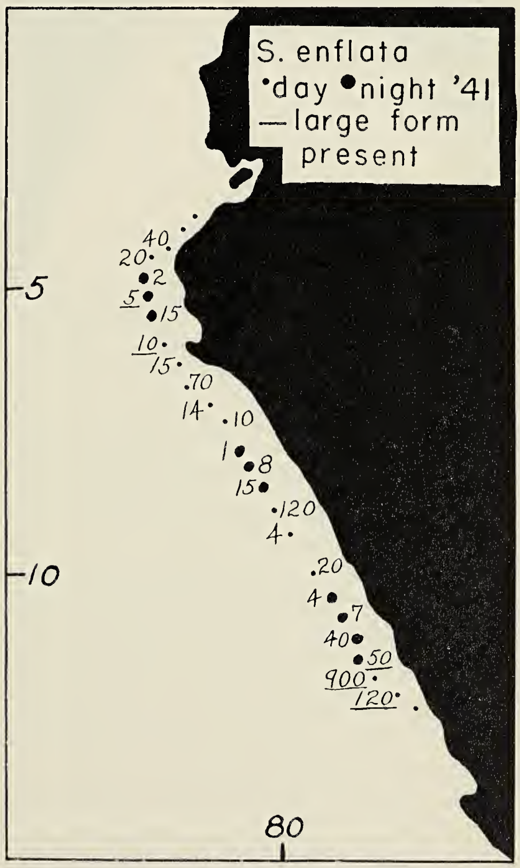


Fig. 7. Occurrence of *Sagitta enflata* off Peru in 1941. A large form of *S. enflata* maturing at a length of 20 mm. or greater occurred at the stations with underlined concentrations.

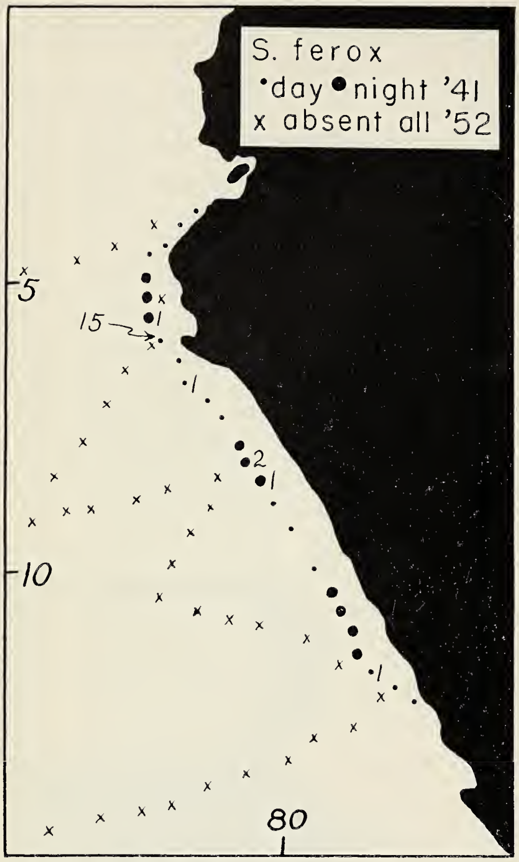


FIG. 8. Distribution of *Sagitta ferox* in 1941 and 1952. Crosses are 1952 stations. *S. ferox* was absent from all 1952 stations.

FIG. 9. Occurrence of *Sagitta hexaptera* off Peru in 1941.

seem somewhat anomalous since it occurs together with equatorial species. Its distribution together with that of *S. minima* indicates complex conditions between stations 14 and 23.

Single specimens of *Sagitta minima* were taken at stations 22 and 19 while five specimens were taken at station 18 and three specimens at 16. This species has a widespread but irregular distribution in the Pacific and is most abundant in cool offshore waters. It occurred sporadically off Peru in 1952.

A single specimen of *Sagitta neglecta* was taken at station 17. In 1952 *S. neglecta* did not occur south of about three degrees south latitude; thus the present record indicates some southward penetration of equatorial water.

Sagitta regularis (Fig. 10) had a distribution similar to *K. pacifica* and *S. ferox* in 1941 and occurred considerably inshore of its limits in 1952. It could have reached this position by intrusion of water from the north or west.

Sagitta robusta (Fig. 11) apparently was more common off Peru in 1941 than in 1952. Since this species is most abundant in warm waters, it indicates warmer water present off Peru in May 1941 than in August 1952.

The *Sagitta serratodentata* group is here split into two populations provisionally called *Sagitta pacifica* (Furnestin, 1953) and *Sagitta* sp. *S. pacifica* has a distribution similar to *P. draco*, *S. enflata*, and *S. hexaptera* and is found at nearly every station in 1941 (Fig. 12).

Sagitta sp. is apparently new to science and will be described in a future publication. It

has a distribution similar to *S. minima* but occurs somewhat deeper than that species. In 1952 it occurred at every station off Peru while in 1941 a single specimen was taken at station 7. Much of this difference is no doubt due to the fact that the 1952 net tows were oblique to about 300 meters, but more extensive sampling of the surface waters off Peru may show that *Sagitta* sp. was unusually scarce there in 1941. A specimen belonging to the *serratodentata* group was taken at station 13 and is for convenience called *S. serratodentata atlantica* since it most closely fits the description given by Thomson (1947). It is considered for the present to be a form of *S. pacifica* and part of that population.

Sagitta tenuis (Fig. 13) occurred at 12 stations in 1941. The taxonomic status of this species has been in doubt for many years. Most workers (Faure, 1952; Fraser, 1952; Tokioka, 1955) have kept *S. tenuis* and *S. friderici* as separate species. The author also held this opinion for some time; however, in the 1941 Peru material a complete set of intergrades exists between *S. friderici* to the south and *S. tenuis* to the north. The same situation has been observed by the author in samples taken off Lower California except that there the *tenuis*-like form is to the south and the *friderici*-like form to the north. Michael (1911) called this species *Sagitta bipunctata*. In view of these intergrades, it would appear that *S. tenuis* and *S. friderici* are ecotypic variants of a single interbreeding population or species. Because

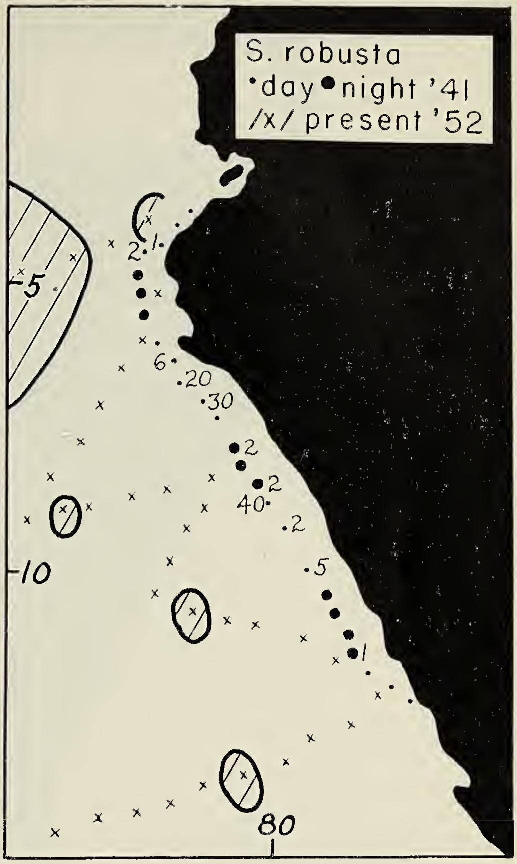


FIG. 11. Distribution of *Sagitta robusta* in 1941 and 1952. Crosses with hatchure—present 1952, without hatchure—absent 1952.

FIG. 10. Distribution of *Sagitta regularis* in 1941 and 1952. Crosses with hatchure—present 1952, without hatchure—absent 1952.

FIG. 12. Occurrence of *Sagitta pacifica* off Peru in 1941.

of the great variability of the species, it is the author's opinion that *S. setosa*, living in water of reduced salinity, is also a form of the species and is interbreeding with the population in the eastern Atlantic. However, until this hypothesis can be definitely established or disproved, it seems best to retain the name *S. tenuis* for the species. The correlation of the morphologic variations of this species with its physical environment and the untangling of the involved synonymy will be treated more extensively in a paper on the general biology of the species now in preparation.

In 1952 *S. tenuis* occurred at only three northern stations and was of the large *friderici*-like form. In 1941 this form was found to the south and the small *tenuis*-like form at the northern stations. Apparently in August of 1952 the *tenuis*-like form (warm water) did not extend south of the Gulf of Guayaquil while in 1941 it reached south to the coast of Peru.

CONCLUSION

Although the material available is not as extensive as might be desired, there is no doubt that the May 1941 distribution of chaetognaths off Peru was significantly different from the August 1952 distribution. The relationship of the 1941 and 1952 samples to El Niño and El Aguaje is shown in Figure 14.

The following hypothesis is advanced as an explanation of the data presented above in the hope that it will lead to more thorough and critical field and laboratory investigations to test its validity.

FIG. 13. Distribution of *Sagitta tenuis* off Peru in 1941 and 1952. Crosses with hatchure—present 1952, without hatchure—absent 1952.

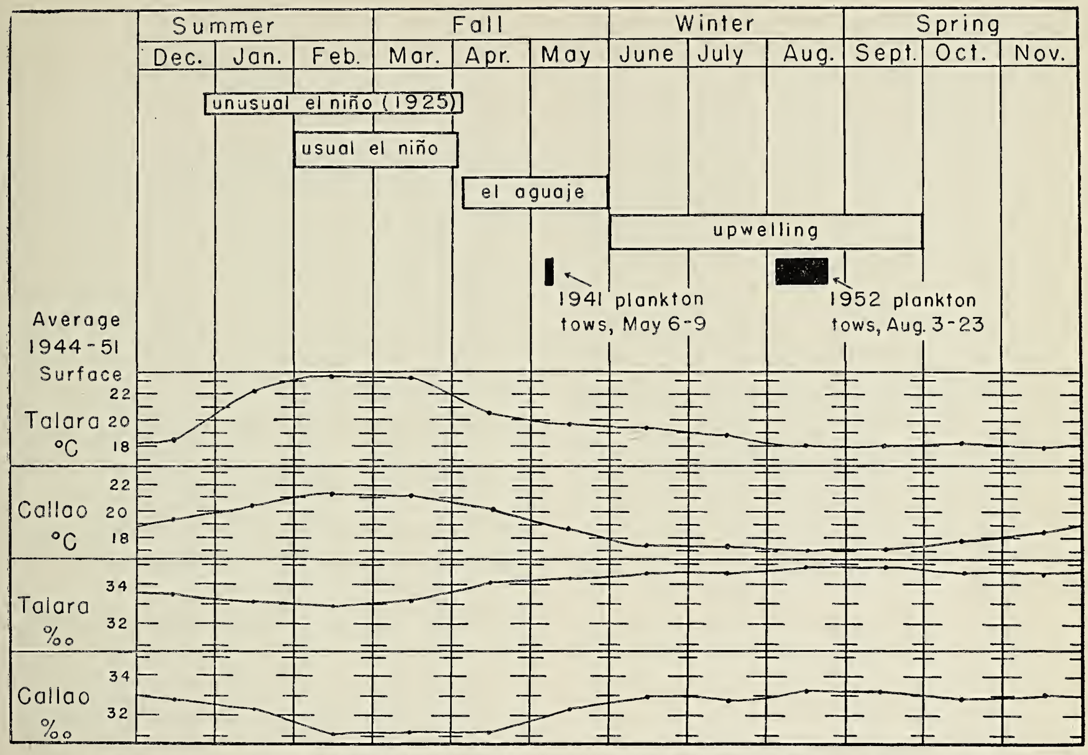


FIG. 14. The relationship of the 1941 and 1952 plankton samples to the physical environment off Peru. The extent in time of El Niño, El Aguaje, and upwelling are taken from Sverdup, Johnson, and Fleming, 1942. The average surface temperature in degrees centigrade and surface salinity in 0/00 are based on Coast and Geodetic Survey publications 280 and 281. The increase in temperature and concurrent decrease in salinity during the months of January through April are conspicuous.

The August 1952 samples, indicating cool water conditions, are probably more representative of the usual conditions off Peru than are the May 1941 samples because the Peru coast is characterized by relatively cool water (Fig. 14). El Niño was apparently above average strength in 1941 as indicated by the heavy rainfall that year (Sverdrup *et al.*, 1946; Sears, 1953). The chaetognath population in the surface water off Peru in May 1941 is thought to have been formed from individuals brought in from the west by El Aguaje and mixed with the remnants of a population brought down from the north by El Niño earlier in the year.

Sagitta pulchra, a common species in the Gulf of Panama, was not found in the 1941 samples. This species might occur off Peru at the height of unusually strong penetration of water from the north.

REFERENCES

BALDASSERONI, V. 1915. Chetognati dalle publicazioni R. Istituto di studi superior di Firenze. IN *Raccolte planctoniche fatte dalla R. Nave "Liguria" nel viaggio di circonnavigazione del 1903–05*, 2(5): 85–118.

BOWMAN, T. E. 1955. A new copepod of the genus *Calanus* from the northeastern Pacific with notes on *Calanus tenuicornis* Dana. *Pacific Sci.* 9(4): 413–422.

DAKEN, W. J., and A. N. COLEFAX. 1940. The plankton of the Australian coastal waters off New South Wales. *Sydney Univ., Dept. Zool., Monog.* 1(1): 63–70.

FAURE, M. L. 1952. Contribution a l'étude morphologique et biologique de deux chae-

tognathes des eaux Atlantiques du Maroc: *Sagitta friderici* Ritter-Zahony et *Sagitta bipunctata* Quoy et Gaimard. *Vie et Milieu, Bul. du Lab. Arago de l'Univ. de Paris, Actualités Sci. et Indus.* 3(1):25–43.

FIEDLER, R. H., N. D. JARVIS, and M. J. LOBELL. 1943. *La pesca y las industrias pesqueras en el Peru.* Compañia Administradora del Guano. 371 pp. Lima.

FLEMING, R. H. 1940. A contribution to the oceanography of the Central American region. *6th Pacific Sci. Cong. Proc.* 3: 167–175.

FRASER, J. H. 1952. The Chaetognatha and other zooplankton of the Scottish area and their value as biological indicators of hydrological conditions. *Scottish Home Dept. Mar. Res., Pub.* 2. 52 pp.

FURNESTIN, M. L. 1953. Contribution à l'étude morphologique, biologique et systematic de *Sagitta serrato-dentata* Krohn les eaux atlantiques du Maroc. *Inst. Océanog., Bul.* 50(1025). 39 pp.

GREY, B. B. 1931. Chaetognatha from the Society Islands. *Roy. Soc. Queensland, Proc.* 42: 62–67.

JUHL, R. 1955. Notes on the feeding habits of subsurface yellowfin and bigeye tunas of the eastern tropical Pacific ocean. *Calif. Fish and Game* 4(1): 99–101.

MICHAEL, E. L. 1911. Classification and vertical distribution of the Chaetognatha of the San Diego region including redescriptions of some doubtful species of the group. *Calif. Univ., Pubs., Zool.* 8(3): 21–186.

——— 1913. *Sagitta californica*, n. sp., from the San Diego Region including remarks on its variation and distribution. *Calif. Univ., Pubs., Zool.* 2(5): 89–126.

POSNER, G. S. 1954. The Peru Current. *Sci. Amer.* 190(3): 66–71.

RITTER-ZAHONY, R. 1911. Revision der *Chätognathen. Deutsche Südpolar Exped. 1901–03. Zool.* 5(1). 71 pp.

ROSE, M. 1953. Quelques renseignements sur le plankton des Iles Tuamotu. *Natl. Mus. d'Hist. Nat., Bul.* 25, ser. 2(5): 456–462.

SCHAEFER, M. B. 1954. Report on the investigations of the Inter-American Tropical Tuna Commission for the year 1953. *Inter-Amer. Trop. Tuna Comn., Ann. Rpt., 1953, App. A*: 18–50.

SCHWEIGGER, E. H. 1940. Studies of the Peru coastal current with reference to the extraordinary summer of 1939. *6th Pacific Sci. Cong. Proc.* 3: 177–195.

SEARS, M. 1954. Notes on the Peruvian coastal current. 1. An introduction to the ecology of Pisco Bay. *Deep Sea Res.* 1(3): 141–169.

SVERDRUP, H. U., M. W. JOHNSON, and R. H. FLEMING. 1942. *The Oceans.* 1078 pp. Prentice-Hall, Inc., New York.

THOMSON, J. M. 1947. The Chaetognatha of southeastern Australia. *Austral. Council Sci. & Indus. Res., Bul.* 222. 43 pp.

TOKIOKA, T. 1939. Chaetognaths collected chiefly from the bays of Sagami and Suruga, with notes on the shape and structure of the seminal vesicle. *Rec. Oceanog. Works in Japan* 10(2): 123–150.

——— 1940. The chaetognath fauna of the waters of Western Japan. *Rec. Oceanog. Works in Japan* 12(1). 22 pp.

——— 1955. Notes on some chaetognaths from the Gulf of Mexico. *Mar. Sci. Gulf Carib., Bul.* 5(1): 52–65.

U. S. COAST AND GEODETIC SURVEY. 1952. *Surface Water Temperatures at Tide Stations, Pacific Coast North and South America and Pacific Ocean Islands.* U. S. Dept. Com. Spec. Pub. 280. 59 pp.

——— 1954. *Density of Sea Water at Tide Stations, Pacific Coast North and South America and Pacific Ocean Islands.* U. S. Dept. Com., Washington. 63 pp.

WILSON, R. C., and B. M. SHIMADA. 1955. Tuna longlining results of a cruise to the eastern tropical Pacific Ocean. *Calif. Fish and Game* 41(1): 91–98.

WOOSTER, W. S., and F. JENNINGS. 1955. Exploratory oceanographic observations in the eastern tropical Pacific, January to March, 1953. *Calif. Fish and Game* 41(1): 79–90.

Redescription of *Teredicola typica* C. B. Wilson (Crustacea: Copepoda)

Mildred Stratton Wilson[1]

Since 1942 *Teredicola typica* has been known to be associated with shipworms in the Hawaiian Islands, but neither the genus nor species has been reported in literature from any other locality, or from any other host group. Dr. C. H. Edmondson of the Bernice P. Bishop Museum, who made the original collections of this interesting copepod, has stated in personal correspondence that he has inquired about the occurrence of copepods in shipworms around the world, but has not yet found anyone who has encountered this parasite. Recently, another copepod parasite has been discovered in *Teredo petiti* from "lagoons of western Africa" by Rancurel (1954). This copepod, for which a new genus *Teredophilus* has been proposed, does not seem on the basis of the description to bear any close relationship to *Teredicola* (see Discussion).

The original description of *Teredicola typica* was made by Dr. Charles B. Wilson in a posthumous paper (1942) and was repeated without emendation in 1944. Records of occurrence of the copepod in the Hawaiian Islands, and observations on its habits and early development are given in papers by Edmondson (1942, 1945). Some corrections and additions to the original description have been made by M. S. Wilson and Illg (1955) in a paper outlining the history and interpretations of the family Clausiidae to which *Teredicola* is referred. The purpose of the present paper is to place on record a revised and amplified description with illustrations of all the appendages, some of which were omitted or confused in the original description.

The specimens examined were from collections of *Teredo milleri* made in Honolulu harbor, January 10, 1945, by Dr. C. H. Edmondson. I wish to acknowledge Dr. Edmondson's cooperation in this study.

Teredicola typica C. B. Wilson, new description
Figs. 1–19

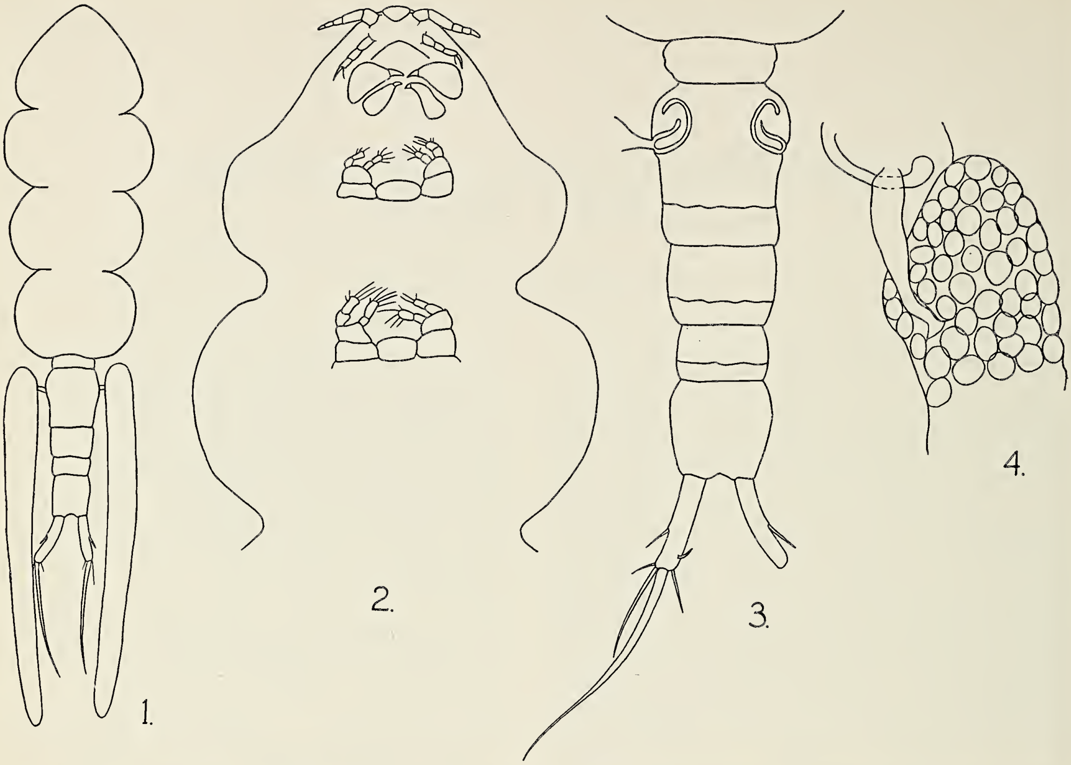
Teredicola typica C. B. Wilson, 1942: 60, fig. 1 a–h; 1944:539, pl. 31, figs. 172–179.
Teredicola typica, Edmondson, 1942:145, fig. 13; 1945:220, figs. 1–3.
Teredicola typica, M. S. Wilson and Illg, 1955: 132.

Length (of specimens examined), female, 4.0–4.71 mm.; male, 1.76–2.21 mm.

FEMALE (Fig. 1). Metasome of four expanded segments; urosome of five posterior segments reduced in width to about one-third of that of last metasome segment. Metasome segments usually swollen and fleshy, dorsally rounded, constricted laterally between segments; integument thin to relatively heavy. Somite of leg 1 united with cephalic segment to form metasome segment 1 (Fig. 2); shape of segment variable, ranging from that with sloped outer margin (Fig. 1) to that with distinct, rounded, distal expansions (Fig. 2).

Urosome segment 1 of female (somite of leg 5) the shortest, marginally free or entirely recessed into last expanded segment of metasome and not visible dorsally; no remnants

[1] Arctic Health Research Center, United States Public Health Service, Anchorage, Alaska. Manuscript received August 7, 1956.

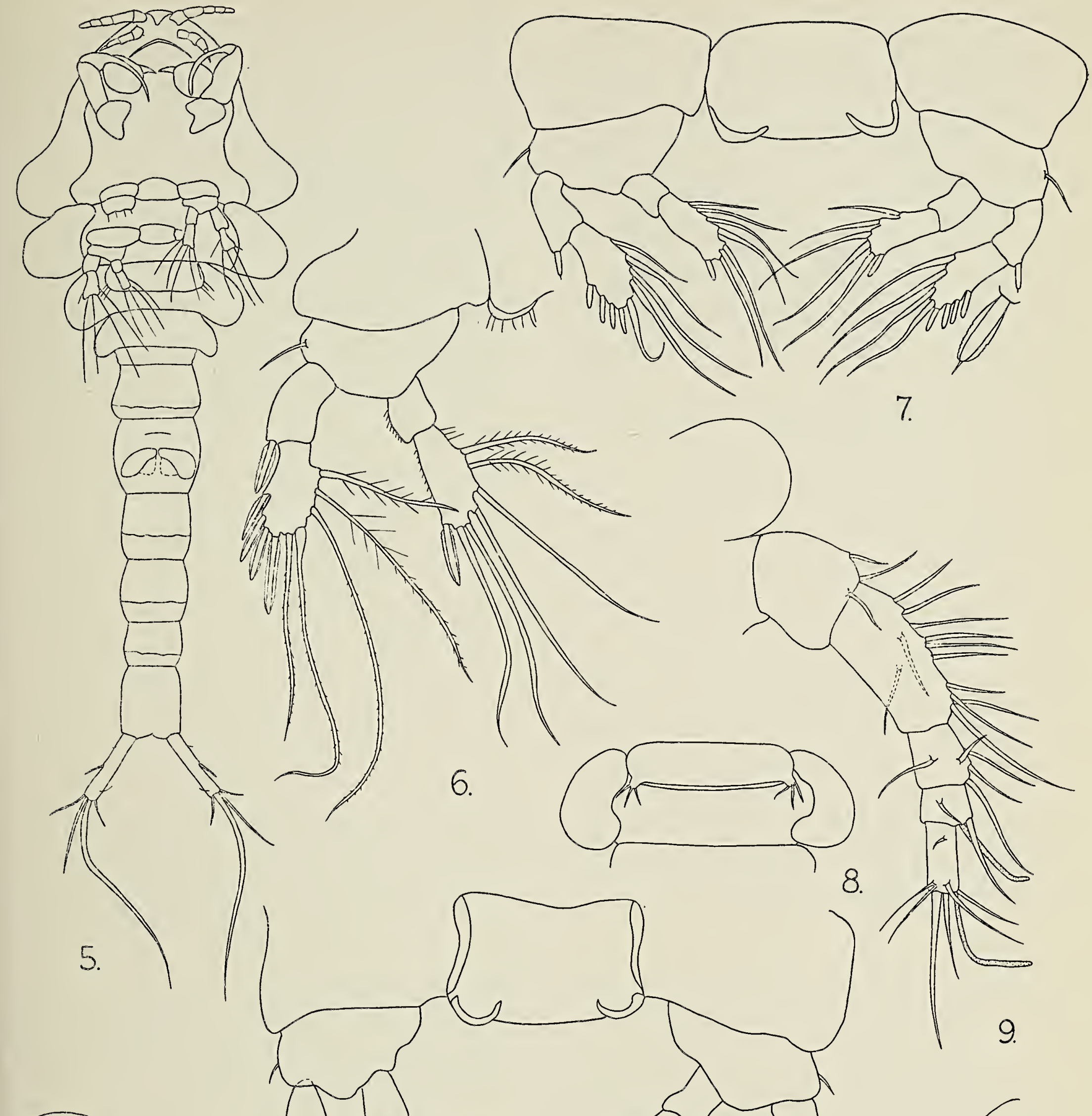


FIGS. 1–4. *Teredicola typica*, female. 1, Habitus, dorsal. 2, Metasome segments 1–2, ventral, showing placement of cephalic appendages and legs 1–2 (same scale as male, Fig. 5). 3, Urosome, dorsal (including thoracic somite 5). 4, Detail of attachment of ovisac.

of leg 5 present. Integument of urosome relatively thin; usually the segments entirely expanded, leaving their broad intersegmental membranes clearly defined both ventrally and dorsally (this shown by wavy line in Fig. 3). Genital segment (urosome segment 2) the longest, proximal portion with slightly rounded lateral expansions. Genital openings dorso-lateral in position, reinforced by strong external sclerotized framework on dorsum (Fig. 3). Ovisacs attached to opening by long, expandable membrane so that the cylindrical sacs are held away from body in "floating" position (Figs. 1 and 4). Sacs reaching beyond caudal rami, attaining length equal to that of metasome or more; with numerous, very small eggs (Fig. 4).

Last urosome segment of female (anal segment) longer than either of two preceding segments and subequal in length to caudal rami; proximal part widened. Rami more or less divergent, slender, length about 4 times greatest width; armed outwardly with short seta placed just below middle and terminally with four setae, the third from outside much stouter and longer than others, its length about 2.5 times that of ramus; small seta placed subapically on inner, dorsal margin.

MALE (Fig. 5). Metasome not swollen as in female but with strongly integumented, laterally expanded dorsal plates broadly curved under ventrally. Lateral expansions of first two segments prominent; those of segments 3 and 4 rather abruptly contracted in width making the division between metasome and urosome less prominent than in female. Fore part of lateral margin of cephalic segment usually gradually and gracefully curved backwards to distal, rounded expansion, but sometimes the whole margin sloped, thus exhibit-



FIGS. 5–12. *Teredicola typica*. 5, Male, habitus, ventral (same scale as female, Fig. 2). 6, Male, leg 1 (same scale as Fig. 7). 7, Female, leg 1, with detail of spine. 8, Male, metasome segment 3, ventral, showing detail rudimentary leg 3. 9, Female, antennule. 10, Male, maxilliped. 11, Female, leg 2. 12, Female, antenna.

ing a variability similar to that found in female. Intersegmental membranes of metasome segment 4 and of urosome segments frequently expanded as in female. Urosome of six segments, width decreased only slightly from that of fourth metasome segment. Genital segment ventrally with pair of external lappets with sclerotized edges, flaplike and protuberant on their distal and internal margins. Anal segment elongated as in female. Caudal rami divergent, with setal armature as in female.

Rostrum not prominent, nongeniculate, appressed to ventral face or partially protuberant in either sex.

Antennule (Fig. 9) closely similar in male and female; extremely short, not equaling more than one-fourth of length of cephalic segment; 5-segmented. Second segment much the longest. All segments bearing nonplumose, thinly integumented setae; mostly shorter or only little longer than width of segment in female, relatively longer in male. Longest seta apical, equal to about combined lengths of segments 3–5. A weakly developed, terminally placed aesthete on segments 4 and 5. Relative length of segments and number of setae (s) and aesthetes (a):

Segment	1	2	3	4	5	
Length	26	38	12	10	14	= 100
Armature	3s	12s	5s	2s	7s	
				a	a	

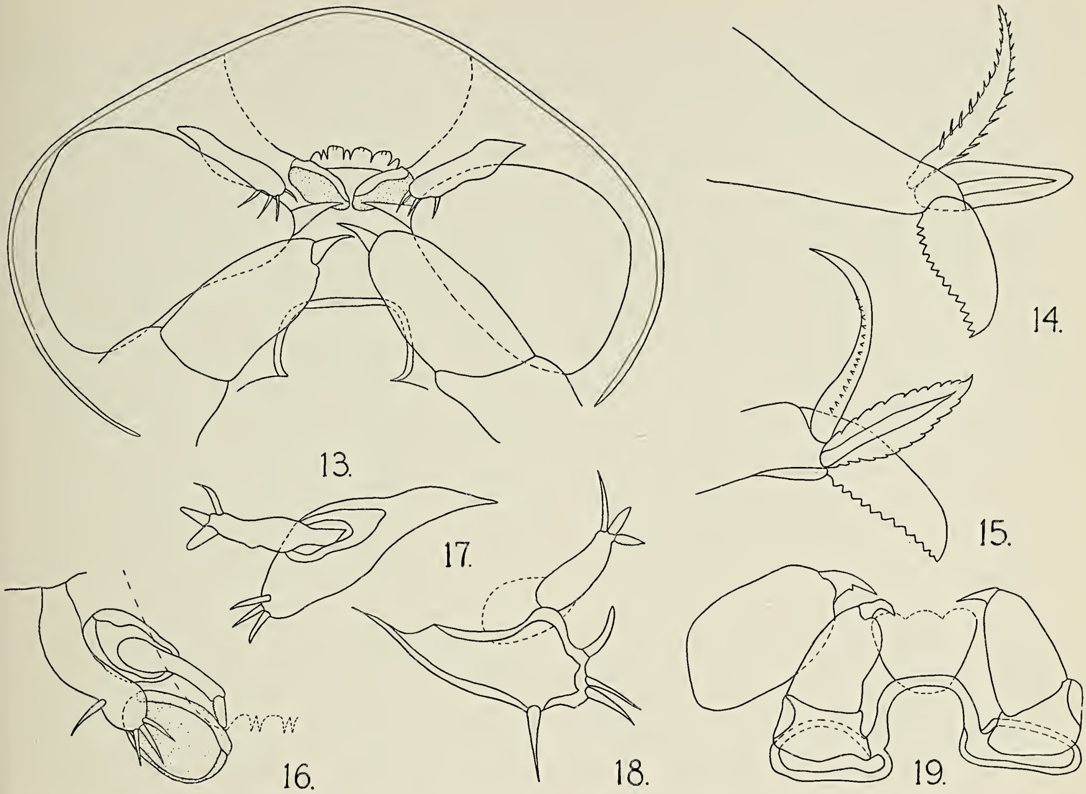
Antenna (Fig. 12) alike in sexes though relatively larger in male than in female, its four segments progressively shortened from base to apex. Apical segment reduced to about half of width of third segment and offset laterally, bearing terminally two stout, clawlike setae and two slender, flexible setae of which the outer is much the shorter. Third segment bearing stout, curved claw on free apical portion; at its base a hairlike seta and small, marginal, serrate process.

Buccal mass outwardly protuberant from ventral face; labrum and its extensive framework forming anterior medial support, maxillipeds and their medial framework (Fig. 19) giving posterior support. Labrum united laterally with the likewise protuberant membrane of ventral face and surrounding tissue mass; its free posterior edge with irregular, sometimes bifid spinous points (Fig. 13). Mandible (first free appendage) entirely covered by labrum, set in a sclerotized framework, seemingly embedded in fold of the lateral protruding membrane of ventral face; with short, stemlike basal portion to whose slightly enlarged, somewhat conical end is attached ventrally a posteriorly directed "claw" with distal serrate edge, and two dorsally arising accessory pieces—one foliate in outline, the other a stout, serrate seta (Figs. 14 and 15). First maxilla larger than mandible, arising laterally beyond its base; attachment to lateral protuberant surface membrane clearly distinct (Fig. 16); *in situ* appearing sinuous and elongate though actually somewhat broadened dorso-ventrally; its margin faintly sclerotized (Fig. 18); bearing a single seta on inner posterior margin and a group of three apical setae. Just inside apices of first maxillae and immediately distad to midline of labrum, a pair of simple, hardly protuberant, unornamented lobes interpreted as paragnaths. These lobes partially covering anterior edge of distally extended structure interpreted as extension of (or support of) labium (Fig. 19); its posterior edge supported by protrusion of anterior part of medial framework of maxillipeds (Fig. 19).

Second maxilla with hugely expanded, membranous basal portion and simple terminal claw (Fig. 13). Maxilliped of female smaller but stouter in structure than maxilla, more or less divided into two segments, of which the second is the longer; armed apically with short, stout, curved claw.

Oral area of male like that of female, except that maxillipeds (Figs. 5 and 10) more stoutly developed, ending in long curved claw reaching back to basal origin of appendage.

Only two pairs of legs present in both sexes (legs 1, 2), much reduced in size (Figs.



FIGS. 13–19. *Teredicola typica*, female. 13, Oral area *in situ*, diagrammatic. 14, Mandible apex, ventral. 15, Mandible apex, dorsal. 16, Schematic diagram, latero-ventral view, showing arrangement of labrum (dashed lines), mandible, first maxilla, and paragnath. 17, Mandible and basal framework overlying first maxilla, showing distortion due to cover glass pressure. 18, Same as 17, different view. 19, Second maxilla and maxillipeds with skeletal framework *in situ*, viewed from below.

2 and 5), those of male comparatively and actually larger than those of female. Both segments of basipod and connecting piece well developed; segment 2 usually with slender outer seta, otherwise unarmed. Both rami 2-segmented, much reduced in size, their length less than basipod in female, about same in male. Spines modified; flat, with narrow, faintly serrate, hyaline membrane on margins; usually tipped with free minute point. Setae variously developed, tending to have enlarged bases, mostly longer than segment, non-plumose in female, sparsely so in male. Exopod segment 1 with single outer spine, endopod segment 1 unarmed. Number of spines on second segment of exopod and endopod of both pairs of legs alike in male and female and tending to be constant; varying a little in size, especially in female; those of male larger than those of female (Fig. 6). Number of setae of second segment variable, both from specimen to specimen and from left to right ramus of a pair (Table 1).

No remnants of other legs in female. In male, a group of three setae present on slightly produced portion of widened ventral plate of third metasomal segment, interpretable as rudiments of leg 3 (Fig. 8).

VARIATION

There does not appear to be any question that the different lots of specimens examined by C. B. Wilson and myself represent the same

TABLE 1

SUMMARY OF SETATION OF SECOND SEGMENT OF LEGS FOUND IN TWELVE SPECIMENS OF *Teredicola typica* (sp = spine; s = seta; number in parentheses represents that of opposite ramus; in two females the segment was previously broken off on one side, as indicated by blank space.)

	LEG 1				LEG 2			
	Exopod 2		Endopod 2		Exopod 2		Endopod 2	
♀	4(4)sp	4(4)s	1(1)sp	5(4)s	3(3)sp	5(5)s	2(2)sp	4(3)s
	4(4)	5(4)	1(1)	6(5)	3(3)	5(4)	2(2)	4(5)
	4(4)	5(6)	1(1)	6(5)	3( )	5( )	2(2)	5(5)
	4( )	5( )	1(1)	5(5)	3(3)	5(4)	2(2)	5(5)
	4(4)	2(3)	1(1)	4(5)	3(3)	4(4)	2(2)	4(5)
	4(3)	3(5)	1(1)	5(5)	3(3)	3(4)	2(1)	4(5)
	4(4)	5(5)	1(1)	6(6)	3(3)	4(5)	2(2)	5(5)
♂	4(4)	5(5)	1(1)	5(6)	3(3)	6(5)	2(2)	4(5)
	4(4)	5(5)	1(1)	6(6)	3(3)	6(6)	2(2)	5(5)
	4(4)	5(5)	1(1)	6(6)	3(3)	5(5)	2(2)	5(5)
	4(4)	4(6)	1(1)	6(7)	3(3)	5(5)	2(2)	5(5)
	4(4)	5(5)	1(1)	6(7)	3(3)	4(5)	2(2)	5(5)

species. The differences between the two descriptions are not due to variation, but to omissions or misinterpretations in the original description. Most of these can be easily reconciled with or explained by comparison of the statements and illustrations in Wilson's description, or with the specimens used in this study.

Teredicola typica clearly shows in both sexes the same recognizable number of body segments most commonly found in both free-living and parasitic cyclopoid copepods—that is, nine segments in the female and ten in the male. As is shown both by Wilson's illustration and those given here, the tumid condition of the anterior part of the female's body does not obliterate the number of segments included in the metasome in either dorsal or ventral view. The lateral expansions are constricted between the segments whether the specimen is newly molted or older, expanded or contracted. The somite of leg 1 is thoroughly united with the cephalic segment as indicated in ventral view (Fig. 2), and the three succeeding expansions are obviously interpretable as the somites of legs 2–4, or thoracic segments 2–4. The fourth thoracic segment cannot be the first reduced segment as given in the original generic diagnosis. Whether any real suture lines are ever present between the expanded segments is difficult to decide with certainty from preserved material. In well expanded specimens, an intersegmental membrane was prominent (Fig. 2), and no definable lines of separation were noticed. In less expanded specimens, complete or incomplete lines were observed, of which some at least were "fold" lines of the membrane. Thus, although highly modified, the metasome of *Teredicola typica* does conform in the female to the "standard" segmentation of other cyclopoids and exhibits external evidence of this.

There are five reduced posterior segments (urosome) in the female, rather than six as shown by Wilson. It follows from the division of the metasome that the first of these is the somite of the absent fifth leg (fifth thoracic segment). The second reduced segment is the genital segment, as is clear from the attachment of the ovisacs, which are shown by Wilson attached to an additional segment posterior to the second segment, an error corrected in an illustration by Edmondson (1945). The extra segment of the urosome shown in this position by both Wilson and

Edmondson can be accounted for by their inclusion of the intersegmental membrane of the genital segment, which is very broad in fully expanded specimens. The integument of the urosome is relatively thin and in the whole lot of preserved specimens that I have examined there was a dominant tendency for prominent expansion of all the segments as shown in Figure 3. There is no striking differentiation between the segmental margin and its membrane and the number of true segments could easily be misinterpreted.

In the lot of specimens examined, only one was found in which the segments of the urosome were fully contracted. Between this condition and the fully expanded specimens, intermediates were found. True length measurements of individual specimens are therefore difficult to achieve. There is, however, no doubt that there are considerable real as well as superficial differences in total length between specimens. From my observation, the range of length measurements given in the literature is reasonably accurate (female, from about 4.0–5.0 mm., male, 1.75–2.35 mm.).

Because of the variation found in the shape of the cephalic segment in both sexes, examples of the extremes of these conditions were particularly examined in detail for possible correlated differences in both body and appendages, but none were found.

The caudal rami exhibit many degrees of divergence in both sexes and it seems evident that this divergence results from an extremely flexible attachment rather than from any real individual or sexual variability. No sexual dimorphism was found in the number or relative size of the caudal setae, although as happens in all copepods, they were at times broken. Most of them are very slender and can be observed accurately only at high magnification.

No variation was found in the segmentation of the antennule. Both Wilson's figures and his statement that the basal segment is nonsetiferous, points to his inclusion of the surface eminence to which the antennule is attached, giving six rather than five segments. When his illustrations are interpreted as 5-segmented antennules, the relative lengths of the segments correspond closely to those given here, the second segment being much the longest.

Wilson neither figured nor described the actual antenna. In the text, it is mentioned only in the generic diagnosis of the male, in which it is described as "2-segmented, prehensile." His figure labeled "second antenna of female" is obviously either the second maxilla or the maxilliped of the female, probably the latter. No other cephalic appendages were described.

It is impossible to accept as a variation or to explain Wilson's observation that two outer setae (or short spines) are present on the first exopod segments of the legs, instead of the one spine observed in all my dissections. In the Copepoda, two spines have been found on this segment only in the Platycopiidae, a family far removed from these cyclopoid parasites. It is difficult to accept this even as an anomaly, nor is there present any cuticular spinous production of the segment itself to allow for misinterpretation. Otherwise, Wilson's figures agree fairly well with the legs examined in this study, though neither the asymmetry nor the variation in the number of setae was noted.

The number of spines on the second exopod and endopod segments of the legs appears to follow a pattern, but even this may be disturbed as shown by the female specimen in which one exopod of leg 1 and one endopod of leg 2 had the usual spinal number reduced (Table 1). Asymmetry of setation was the rule in the females dissected, no individual being found with right and left rami alike in both legs. Though two males had both pairs symmetrical, the two specimens did not completely agree with one another. It is evident from these observations that the setal formula can be used for specific differentiation in this genus only upon examination of several specimens.

INTERPRETATION OF ORAL AREA

The highly modified and usually compact oral areas of poecilostome cyclopoids present particularly difficult problems in both the technical and graphical aspects of their study. Doubtless this has contributed to the differing interpretations of their anatomical features and the omission from many descriptions of all or part of the appendages. The viewpoint has already been expressed that "no species or genus should be proposed without thorough delineation of all the appendages" (M. S. Wilson and Illg, 1955). It is, of course, obvious that neither a taxonomy adequate for identification and differentiation of species, nor one that will contribute to classificatory knowledge, can result from neglect of some parts or mere cursory examination of others.

The illustrations presented here for *Teredicola typica* are diagrammatic and their understanding may be helped by further elucidation of some points. As noted in the description, the buccal mass is protuberant. It is supported anteriorly by the labrum and its framework and posteriorly by the maxillipeds and their framework (Fig. 19). An apparently newly molted specimen, relatively nonfleshy and with thin body membranes, was used for Figure 13. It is a camera lucida drawing from an *in toto* preparation, slightly flattened by cover glass pressure, and viewed ventrally with the compound microscope. Its illustration cannot be other than diagrammatic, since the original is of necessity distorted, but such a view does establish the continuing relationship of the parts, which is impossible to show otherwise.

The labrum is strongly united with the likewise laterally protuberant surface membranes, though a lightly sclerotized line appears to define its actual lateral boundaries (shown by dashed lines in Fig. 13). The ventral posterior edge is free and protuberant.

The mandible is entirely hidden in an *in toto* view, both because of its small size and its location below the labrum. It seems to be somewhat separated from the other appendages by a slight fold of the laterally protuberant membrane. As verified from dissection, the base arises from a shallow framework of anastomosed, sclerotized strands, from which it was usually automatically separated during the manipulation of dissection. Because of the extreme reduction in size of the whole appendage, the apical pieces of the right and left mandibles possibly may not meet one another in midline, but this was not exactly determined. They do, however, reach at least to the free posterior edge of the labrum, below which the oral opening is presumably situated. Figure 16 shows schematically the relationship of the mandible, maxilla, and paragnaths to the labrum. The exact placement of the appendages and other structures may perhaps be more easily determined from early copepodid stages in which the buccal mass is probably not so fleshy and protuberant.

In situ, the first maxilla is elongate and appears to lie along the top of the inflated basal part of the second maxilla (Fig. 13). In actuality, its medial portion is slightly expanded dorso-ventrally, and lies close to the likewise expanded top portion of the second maxilla. In dissection, the two maxillae were frequently separated together, entirely free from the mandible.

Since the relationship of the two anterior appendages in poecilostome cyclopoids has been much disputed in literature, some comments on their relationship and structure in *Teredicola* are appropriate here. The stemlike portion of the mandible appears to be attached to its skeletal framework near the apex of the first maxilla. When the whole buccal mass or separated anterior portions of it were observed and manipulated under the stereoscopic microscope in lateral view and from above, it was clear that the mandible is more deeply embedded (that is, more dorsally situated) than any part of the maxilla. This is a normal and expected condition when the protuberant nature of the whole mass is con-

sidered. When the two appendages were dissected together with their surrounding tissue mass and viewed laterally, the more dorsal origin of the mandible and the separate insertions of the two appendages were clearly apparent.

Preparations of some of these dissections made for study of detail under high power objectives are particularly instructive as examples of distortion due to cover glass pressure. Figures 17 and 18 are diagrams of two examples of such mounts. In each the anterior appendage (mandible) and a portion of the framework from which it arises, partly overlies or underlies the posterior appendage (first maxilla) and appears to be attached to the latter. The study and illustration of prepared mounts such as these, in which the two appendages lie in a wholly unnatural relationship, have probably been responsible for or have at least contributed to the continuing argument as to whether or not Sars (1918) was correct in interpreting these two appendages as the maxilla and its attached palp. In this instance, however, if there were a real attachment between these two appendages, the condition in *Teredicola* would represent a reversal of the Sarsian interpretation inasmuch as the smaller anterior appendage (the maxilla of Sars) would be attached to the larger posterior appendage (the palp of Sars). The reduced anterior appendage of *Teredicola* corresponds structurally to the main body of the maxilla of Sars by virtue of its modified apical armature. The larger posterior portion corresponds in its simple setal armature to the so-called palp of other poecilostomes. Quite obviously, if the condition shown in Figure 17 were realistic, it would negate the argument that the first free appendage must be called a maxilla because its armature resembles portions of that found in some other copepods.

It may be useful to other workers to include here some personal remarks about the requirements and techniques of study of the oral area of poecilostomes. It seems to me that, in addition to knowing the details of isolated appendages, it is instructive to know their relationship to one another *in situ*, and to the other structures and the framework of the mass. At least schematic drawings of the whole oral area should be included in descriptions of new or little known genera. In species in which the cephalic segment is tumid, as it is in *Teredicola typica*, it is necessary to remove the buccal mass *in toto* from the ventral face, not only for its own study, but for dissection of appendages. Attention is drawn here to the micro-shears designed by C. S. Wilson (1953), because they greatly facilitate work with such fleshy masses.

In poecilostomes with extremely compact, fleshy, or protuberant masses and highly modified appendages, I have found it essential for personal understanding of the relationships of the appendages to the buccal mass and to one another to study unmounted material and to alternate the study between the stereoscopic and compound microscopes. Although it is not possible to secure high enough magnification for study of detail with the stereoscopic microscope, it does give the third dimensional, natural depth that is lacking in views under the compound, and contributes greatly to interpretation.

SYSTEMATIC POSITION

Teredicola has been referred to the family Clausiidae (M. S. Wilson and Illg, 1955) in a revised and restricted definition limiting the family to the genera *Clausia*, *Seridium*, *Mesnilia*, *Teredicola*, and the inadequately known *Rhodinicola*. The close relationship of this family to the Clausidiidae is pointed out, and the intermediate condition of the apical armature of the mandible of *Teredicola* used to suggest that further study may lead to a merging of the two families or establishment of an inclusive, higher category.

It is not necessary to discuss the classification further since the matter has been dealt with in the previous paper. In assigning other species to *Teredicola*, it will probably be found

that the fundamental characters as outlined for the family are likewise of basic value on the generic level. Congeners of *Teredicola typica* may be expected to exhibit the following characters:

1. A close similarity of the antenna and apical pieces of the mandible to those of *typica*.

2. Both maxillae simple in structure.

3. Maxilliped present in both sexes; dimorphic.

4. Paragnaths rudimentary or well developed.

5. Legs reduced in size, 1–4 pairs present.

6. Leg 5 probably absent; if present unlikely to be more than rudimentary.

7. Body shape variable, segmentation of metasome distinct or not in female; sexual dimorphism probably conspicuous.

Because of the interest of their occurrence in the same host group, mention should be made here of the new genus *Teredophilus* proposed by Rancurel (1954). In comparing this genus with others, Rancurel has followed a common misconception that relationships can be determined by purely specific characters such as size, habitus, segmentation of the antennules, and the number of legs. The genus is compared only with genera such as *Teredicola* which have been impossible to place accurately in families, or in some cases even to recognize, because the oral appendages have been omitted or only partially elucidated in their descriptions. The conclusion that *Teredophilus* is most closely related to *Ischnurella* has no real foundation when based upon the scanty description given by Pelseneer (1929).

On the basis of present knowledge, it does not seem possible to place *Teredophilus* systematically. It shows certain relationship with the ergasilids in the simple but stoutly prehensile antenna and in the shape and armature (reduction of spines) of legs 1–4. But in spite of the drawings and description given, I find it difficult to interpret satisfactorily the oral area and appendages, so that these suggested ergasilid characters may be very misleading. The copepod is very small (0.70 mm.) and undoubtedly the oral area is exceedingly difficult to study. Rancurel himself gives the impression that his description of this area is incomplete, even as regards the number of appendages, one (or some) of which he refers to in general terms as "machoires." It is therefore necessary that the oral area be presented again in literature with more certain delineation and against a background concept of the significance of the anterior appendages in both generic diagnosis and classification.

REFERENCES

EDMONDSON, CHARLES H. 1942. Teredinidae of Hawaii. *Bernice P. Bishop Mus., Occas. Papers* 17(10):97–150, 13 figs.

——— 1945. Natural enemies of shipworms in Hawaii. *Amer. Micros. Soc., Trans.* 64(3): 220–224, 1 pl.

PELSENEER, PAUL. 1929. Copepodes parasites de mollusques. *Soc. Roy. Zool. de Belg. Ann.* (1928) 69: 33–49, 5 figs.

RANCUREL, P. 1954. Un nouveau copepode parasite de taret: *Teredophilus renicola. Inst. Franç. d'Afrique Noire, Bul. ser.* A. 16(3): 848–858, 11 figs.

SARS, G. O. 1913–1918. An Account of the Crustacea of Norway. 6. *Copepoda Cyclopoida.* 225 pp., pls. 1–118. Bergen Museum, Bergen.

WILSON, CHARLES B. 1942. Description of a new genus and species of copepod parasitic in a shipworm. *Wash. Acad. Sci., Jour.* 32(2): 60–62, 1 fig.

——— 1944. Parasitic copepods in the United States National Museum. *U. S. Natl. Mus., Proc.* 90: 529–582, pls. 20–34.

WILSON, CHARLES S. 1953. Minute shears and forceps from razor blades for fine dissections. *Amer. Micros. Soc., Trans.* 72(4): 379-383, 2 figs.

WILSON, MILDRED S., and PAUL L. ILLG. 1955. The Family Clausiidae (Copepoda, Cyclopoida). *Biol. Soc. Wash., Proc.* 68: 129–141.

Micronesian Reef-associated Gastropods

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THIS REPORT is a synopsis of existing knowledge of the ecology and zoogeography of Micronesian reef-associated gastropods. It summarizes for each species the environmental conditions in which living specimens have been found, and it outlines the recent geographic occurrence of each species throughout the entire Indo-Pacific region (see Plate 4). Brief descriptions of the shells, with illustrations of some of them and reference to published figures for all of them, are also included. The report is intended both as an aid to research by others and as a guide for future collectors. It is based mainly on the notes and collections of field parties whose work in Micronesia since 1945 has increased both the data and the demand for such a summary.

The fact that a similar study has not been made before reflects, perhaps, the paucity of ecologic data in previous collections. Indeed, the extensive Indo-Pacific mollusk collection in the U. S. National Museum, which so substantially supplemented the zoogeographic and systematic parts of this paper, is almost devoid of ecologic records for specimens collected earlier than about 1945.

The information summarized here is surely not the complete or final story for the gastropods. Originally it was hoped to include the pelecypods as well, and, in addition, to attempt a more comprehensive general analysis of the whole group; but time did not permit such a complete study, and it is hoped that these aspects of the gastropods will be covered in later publications.

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SOURCES OF DATA

The ecologic data on which this study is based are taken from eight collections of mollusks made in Micronesia since 1944, comprising about 12,000 lots and over 200,000 specimens. The collections are from Onotoa Atoll in the Gilbert Islands, from Saipan in the Mariana Islands, from Yap and Ifaluk in the West Caroline Islands, and from Bikini, Eniwetok, Rongerik, Rongelap, Arno, and Majuro atolls in the Marshall Islands. All of these islands lie within the geographic area of Micronesia, as outlined in Plate 4. Details regarding principal collectors, sponsoring organizations, size of collections, and dates of field studies are given in Table 1. These collections have been added to those in the U. S. National Museum.

Geographic distribution data, shell measurements and descriptions, and estimates of relative abundance are based on the entire Indo-Pacific collection in the U. S. National Museum.

Supplementary information, zoogeographic, systematic, and ecologic, has been obtained from published records and from personal communications. For the ecologic summaries, unless otherwise specified, only data referring to specimens taken alive or obviously recently dead were accepted, in order to be reasonably sure that the species actually lived in the environment described for them.

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TABLE 1

Recent Micronesian Collections of Gastropods Included in This Study

AREA	SPONSORING ORGANIZATION	FINANCIAL SPONSORSHIP	DATE	PRINCIPAL COLLECTORS	NUMBER OF LOTS	NUMBER OF SPECIMENS
Ifaluk Atoll, Caroline Islands	Pacific Science Board, National Research Council	Office of Naval Research	1953	Frederick M. Bayer, U. S. National Museum	417	2,000
Onotoa Atoll, Gilbert Islands	Pacific Science Board, National Research Council	Office of Naval Research	1951	Preston E. Cloud, Jr., U. S. Geological Survey; Donald E. Strasburg and A. H. Banner, University of Hawaii	301	4,000
Arno Atoll, Marshall Islands	Pacific Science Board, National Research Council	Office of Naval Research	1950	Robert W. Hiatt, University of Hawaii	324	3,000
Yap Island, Caroline Islands	University of Hawaii	University of Hawaii	1945	Robert W. Hiatt, University of Hawaii		
Saipan, Mariana Islands	U. S. Geological Survey	U. S. Army, Corps of Engineers	1949	Preston E. Cloud, Jr., U. S. Geological Survey	124	500
Bikini, Eniwetok, Rongerik, and Rongelap atolls, Marshall Islands	U. S. Armed Forces studies in connection with Operation Crossroads		1946	Joseph P. E. Morrison, U. S. National Museum	10,000	200,000
Bikini, Eniwetok, Rongerik, and Rongelap atolls, Marshall Islands	as above		1947	Joseph P. E. Morrison, U. S. National Museum	650	9,000
Eniwetok Atoll, Marshall Islands	as above		1952	Harry S. Ladd, Martin Russell, and R. C. Townsend, U. S. Geological Survey	67	153

one connected with the Micronesian field studies, especially to the principal collectors named in Table 1. Without them the paper could not have been written at all, since it is mainly a compilation and condensation of their field notes.

Dr. Preston E. Cloud, Jr., Chief, Paleontology and Stratigraphy Branch, U. S. Geological Survey, outlined, supervised, and inspired the project. Without his unfailing support it never would have materialized.

For his encouragement, his advice on systematics, and for providing office space and access to the National collections, I wish to thank Dr. Harald A. Rehder, curator of the Division of Mollusks, U. S. National Museum.

To Mr. Frederick M. Bayer, U. S. National Museum, I am grateful for his patient descriptions of collecting localities and his many kind suggestions.

Dr. R. Tucker Abbott, now at the Philadelphia Academy of Natural Sciences, offered much helpful direction and assistance until and after his departure from the National Museum.

Dr. J. P. E. Morrison, also of the U. S. National Museum, supplied ecologic information and advice.

Miss Carolyn Bartlett, U. S. Geological Survey, prepared the beautiful pen and ink drawings that comprise Figures 1–42 of this report, taking special pains to render the color patterns in monochrome. Mrs. Elinor Stromberg, U. S. Geological Survey, drew the Indo-Pacific map.

Dr. Robert G. Schmidt, U. S. Geological Survey, gave tireless editorial assistance and encouragement.

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GENERAL CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

This report reveals how little is known of the habits of these mollusks. We can hardly begin to understand them without much more extensive field and laboratory studies on such problems as optimum environmental requirements, nutrition, feeding methods, reproduction, egg laying, larval development, growth rates, and anatomy. However, any collector, by keeping accurate detailed notes, can help to answer many questions. The following outline of suitable observations, which could be expanded almost endlessly, is suggested:

Condition of specimen
- Alive
- Recently dead
- Beachworn

Habitat
- Oceanward
  - Seaward reef flat
  - Seaward reef edge
  - Surge channel
  - Offshore ocean water (depth)
  - Other
- Lagoonward
  - Lagoon reef flat
  - Lagoon shelf (depth)
  - Lagoon slope (depth)
  - Lagoon floor (depth)
  - Lagoon reef patch
  - Other

Substrate
- Inorganic
  - Sand
  - Mud
  - Rocks
  - Other
- Organic (living or dead?)
  - Coral (species?—collect for identification)
  - Soft coral (species?—collect for identification)
  - Seaweed (species?—collect for identification)
  - Mollusks (species?—collection for identification)

Mangrove roots
Other

Relation to substrate
Buried (depth)
Attached (method)
Living in crevices, crannies, potholes, tide-pools
Burrowed (e.g., in coral)
Other

Relation to tide
Intertidal
Above high tide line (distance)
Below low tide line (depth)

Type of water
Active breaking surf
Surging water
Calm, protected water
Other

Living habits observed
Solitary or gregarious
Nocturnal or diurnal
Method of feeding
Food (algae, detritus, other organisms—preserve for identification)
Method of locomotion
Associations with other organisms (if any—preserve for identification)
Apparent relationships
Parasitism
Commensalism
Accidental
Reproduction
Breeding habits
Egg-laying procedure
Egg protection or brooding habit (e.g., egg case of *Natica* or brooding habit of *Quoyula*)

Enemies observed
Fish
Birds
Mammals
Invertebrates (e.g., starfish, other mollusks)

The living mollusk
Appearance, particularly color which fades with preservation
Collect soft parts for anatomical study

During the present study it was realized that a single collection by a single worker is likely to give a misleadingly circumscribed picture of a fauna, owing to individual methods and interests. For instance, one person may collect mainly along the shore while another collects principally by diving offshore. It is believed that the present approach, that of compiling information from several collecting methods and viewpoints, is a better one. Since these collections include species from many ecologic zones, a summary of the data of their several collectors presents a more realistic view of Micronesian gastropod ecology than would be likely to result from the notes or efforts of a single collector.

In drawing up the geographic ranges, it became obvious that there are several faunal breaks in the Indo-Pacific region. Time was not available for analysis of these divisions but the basic data are included in the hope that other investigators may take it up. Particularly apparent, however, was the fact that although many species range widely from east to west, almost none of the species occurred farther north than southern Honshu Province, Japan, or farther south than northern Australia. Breaks recognized are almost certainly related to temperature patterns and ocean currents.

It was observed that many species whose geographic distribution is extremely wide are recorded as having pelagic larval stages (for instance many of the Cypraeidae and Cymatiidae, e.g., *Cypraea isabella* and *Cymatium chlorostomum*). It would be of great interest to learn the length of these free-swimming larval stages. Again, it was intended to draw up patterns of zoogeographic distribution and to correlate them with what is known of larval types, but here, too, lack of time precluded such analysis.

Throughout the study, the occurrence of each species around atolls, high islands, and continental shores was noted. The results for a few species (e.g., *Trochus maculatus*, *Nerita*

undata, *Monodonta labio*) imply that these species live only on a muddy substrate such as that found adjacent to high, volcanic islands and continental shores, and that they are not found on the limesand substrate of atolls (or similar parts of other shallow tropic seas). The fact that most species are recorded equally from atolls, high islands, and along continental shores suggests that most of the collections studied are taken from reefs or reef-associated limesands and not from sites strongly influenced by volcanic or terrestrial sedimentation.

SYSTEMATIC ANALYSES

Procedures

Only gastropods in the recent Micronesian collections mentioned are considered in this study. They number 175 species, grouped in 53 genera, and representing 25 families. Because of collecting areas and methods, they are almost exclusively shallow-water forms, which live on or in close association with reefs. The summary provided for each species includes the name apparently regarded as most acceptable by practicing specialists, reference to a convenient published illustration or a drawing made especially for the present work, a brief description of the shell, its ecology as presently understood, its geographic range in the Indo-Pacific, and its abundance in Micronesia.

Taxonomic Arrangement

The brief descriptive notes are intended purely as a field aid to species recognition and not as definitive descriptions or revisions. This is not a taxonomic paper. In general, the systematic arrangement of families and genera is according to Thiele (1929 and 1931). Species are listed alphabetically under each genus. For species which have commonly been recognized by several names, their well-known synonyms are listed parenthetically. The Mitridae are arranged after Dautzenberg (1935), and the Cypraeidae, for the most part, after Schilder (1938). In some instances, where previous authors have subdivided families into many genera which have not gained complete acceptance, those genera are used here as subgenera. For instance, in the Cypraeidae the generic name *Cypraea* is used throughout, whereas the generic names of Schilder (1938) are included as subgenera. In other groups, such as the Conidae and Terebridae, subgeneric names are excluded entirely.

Shell Illustration and Description

As far as possible, reference to a good illustration of each species is provided. Such references are to readily available texts, most frequently to *A Handbook of Illustrated Shells* by Hirase and Taki (1951), *Pacific Sea Shells* by Tinker (1952), *A Field Guide to Shells of the Pacific Coast and Hawaii* by Morris (1952), and to *Coloured Illustrations of the Shells of Japan* by Kira (1955). In a few instances reference is made to "Shells Take You over World Horizons," an article by Platt in the *National Geographic Magazine* (July, 1949).

When an accurate illustration is not available in a convenient reference, pen and ink drawings prepared by Carolyn Bartlett of the U. S. Geological Survey are furnished. Forty-two species are thus illustrated with original drawings; most of these species appear to have been rarely collected although some of them are common or even very common in Micronesia. In these original drawings, the scale marks beside the figures represent one centimeter.

These illustration references and original pen and ink drawings are supplemented by brief descriptions of the shells. For each species, a characteristic shell length is given. In most instances, shell color is noted, particularly if the illustration is in black and white. Obvious sculptural features are also mentioned. For species which are commonly confused with other species, distinguishing characteristics are noted.

Ecologic Summaries

The ecology of each species is compiled from data accompanying the eight Microne-

sian collections previously mentioned. In instances where these collections contain only one or two specimens of a species, the specific collecting data are presented with no attempt at generalization. Unless otherwise qualified, only data referring to specimens taken alive were used. Where observations by collectors are given, e.g., "Bayer reports," with no citation of a publication, the information was obtained by personal communication. For some species, additional remarks from the U. S. National Museum collections and from published accounts for other Indo-Pacific areas are included. Mention is made of associations with other mollusks or other invertebrates, whenever such associations have been reliably reported.

Reef Terminology

In the ecologic notes, an attempt is made to describe reef environments in terms that are self-explanatory and comprehensible to the lay reader as well as to the trained scientist. The aim is to avoid terms that are too specific to apply to reefs in general, since detailed reef characteristics vary from island to island. By and large, the terminology outlined by Tracey, Emery, and Cloud (1955) comes the nearest to that followed here; and for the reader's convenience, their figure 1 is reproduced here, with a few emendations, as Plate 3.

In these discussions, a *Seaward Reef Flat* (Tracey, *et al.* Reef Flat) is the upper surface of an ocean-facing reef. It is also called here an *Ocean Reef Flat*. A *Seaward Reef Flat* is generally broad and well-developed. Its shoreward area (Tracey, *et al.* Inner Reef Flat) is usually intertidal and thus is exposed at low tide, commonly with rocks left standing in residual pools; it is covered by a few feet of water at high tide. Species living in this zone are adapted to periodic exposure or live in tide pools where they are always in water. Because of its variety of habitats, this intertidal part of the *Seaward Reef Flat* is well populated by many species representing several different families.

The seaward part of the *Ocean Reef Flat* (Tracey, *et al.* Outer Reef Flat) is the area immediately shoreward of the *Reef Edge*. It is ordinarily a zone of circulating water but not of heavily breaking surf; it is typically below low tide line and thus is covered by a few inches to a few feet of water at low tide. Species living in this zone are usually never exposed, even at low-low tide. This part of the reef flat is also well populated.

The *Seaward Beach* is at the shoreward-most edge of the *Seaward Reef Flat*. It is characteristically above high tide line. Species which live on or near the *Seaward Beach* (e.g., *Littorina* spp.) are able to survive long periods of exposure to the air. Few species are so adapted; consequently the *Seaward Beach* is sparsely populated. However, empty shells of species living in other areas may be found here.

The *Reef Edge* (Tracey, *et al.* Seaward Reef Margin) is the seaward margin of the *Seaward Reef Flat*. It is intertidal and thus is dry, except for spray, at low tide. The *Reef Edge* is exposed to a heavy surf. Consequently, species living in this habitat must be adapted to withstand the shock of violent wave action. Gastropods living on the *Reef Edge* commonly have a strong muscular foot with which they cling to their precarious homesite (e.g., *Patella stellaeformis*, *Trochus maculatus*). Other workers have called the *Reef Edge* a reef crest, coralline ridge, algal ridge, and *Lithothamnion* ridge. Elongate surge channels or shallow passes indent the *Reef Edge*.

PLATE 1. Truncated and flourishing seaward reef flats. *Above:* Rock surface with patchy thin algal veneer backed at right by beach of alternating loose sand (light) and pitted coral-algal limestone (dark). Embayed windward reef edge and algal ridge at left curves around in distance, Onotoa Atoll, Gilbert Islands. Photograph by P. E. Cloud, Jr. *Below:* Flourishing coral growth at surface of leeward ocean reef without algal ridge, Bikini Atoll, Marshall Islands. Photograph by J. I. Tracey, Jr.

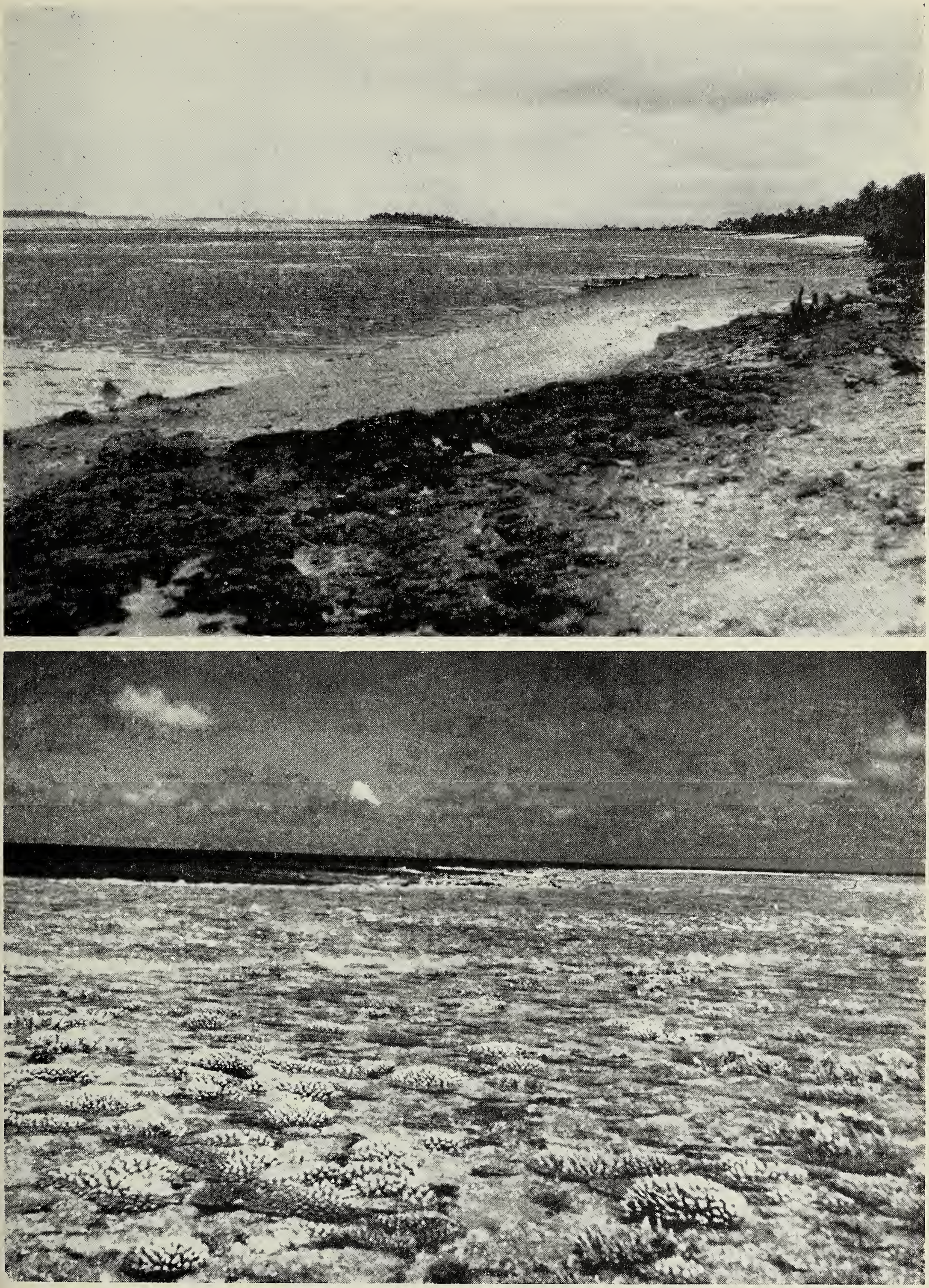


PLATE 1

The *Reef Front* is the shoreward face of a seaward reef, extending from the *Reef Edge* to depths of ± 60 feet, the approximate dwindle point of flourishing coral growth. This habitat is ordinarily one of abundant living coral and other reef-building organisms. The shoreward part of the *Reef Front* is characterized by turbulent water, particularly on a windward reef.

The *Outer Slope* is the steeply descending seaward face of a seaward reef, extending from ± 60 feet (the depth of marked dwindling of abundant living coral and coralline algae) to the deepest seaward portion of the reef. It is a habitat of few or no reef-building organisms, except at the transitional depth of approximately 60 feet. These deeper zones, the *Reef Front* and *Reef Slope*, are seldom mentioned in this report, since, because of collecting methods, most of the gastropods treated here live intertidally or in relatively shallow water.

A *Lagoon Reef Flat* borders the lagoon side of an island. It includes the intertidal zone and depths of a few feet below low tide line. It is generally a poorly developed, narrow reef, characterized by quiet water and sparse coral growth—quite a different environment from a *Seaward Reef Flat*. However, windward *Lagoon Reef Flats* of broad atolls, such as Bikini and Eniwetok, commonly exhibit features similar to those of a *Seaward Reef Flat*, because the long fetch of these lagoons allows the development of surf along the windward shore. Consequently species which typically inhabit *Seaward Reef Flats* are occasionally found living on these well-developed *Lagoon Reef Flats* (e.g., *Drupa morum*, *Drupa ricinus*).

Quite often there is no reef on the lagoon shore. Instead there is a *Lagoon Shelf*. A *Lagoon Shelf* is a gently sloping lagoon shore, including the intertidal zone and depths of a few feet, and sometimes extending as deep as 20 feet into the lagoon. The *Lagoon Shelf* is predominately covered with sand or detrital matter rather than by reef-building organisms. Often growing on this sandy shelf, and offering protection to animals, are seaweeds or small reefs. Gastropods which live on the *Lagoon Shelf* commonly burrow into the sand among eelgrass roots or at the base of small reefs (e.g., *Terebra* spp.).

A *Lagoon Reef Edge* (Tracey, *et al.* Lagoon Reef Margin) is the lagoonward margin of a *Lagoon Reef Flat*. In some places the *Lagoon Reef Edge* is entirely absent. In others, it is ill-defined. In still others, such as the broad atolls of Bikini and Eniwetok, it is well developed and exhibits characteristics comparable to a *Seaward Reef Edge*.

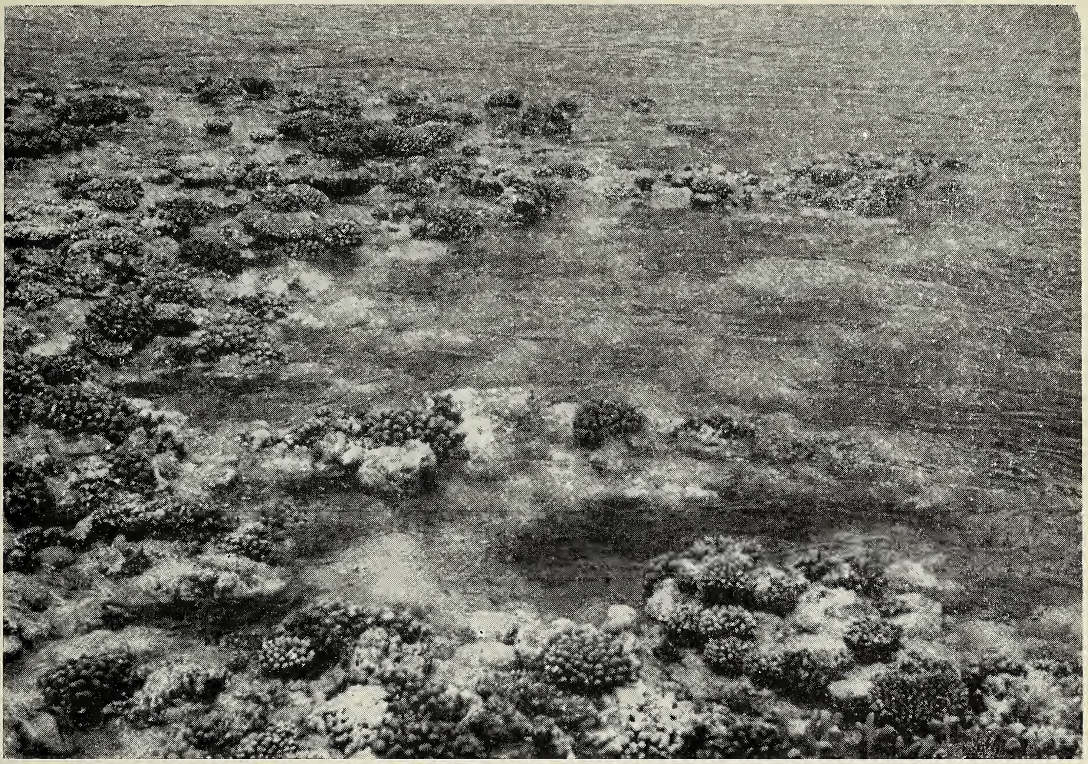
A *Lagoon Slope* is a steeply sloping lagoon border extending from the lower or lagoonward edge of the *Lagoon Shelf* or *Lagoon Reef Flat* to the *Lagoon Floor*. The *Lagoon Floor* is the more or less level bottom of a lagoon.

Subsidiary reefs and minor organic prominences which grow up from lagoon shelves, slopes, and floors are variously shaped as mounds, platforms, knolls, or pinnacles. Many are flat-topped. Names that have been used for such features are patch reefs, reef knolls, and coral knolls. In the present report, because of divergence in collecting notes, these structures are all referred to simply as *Small Lagoon Reefs*.

Zoogeographic Distribution

An outline of the geographic occurrence of each species is given. Such distributional patterns have never previously been assembled for the Indo-Pacific mollusks. Perhaps they will provide a point of departure for future work in zoogeography.

PLATE 2. Protected seaward reef margin and reef front pinnacle, Ine, Arno Atoll, Marshall Islands. Photographs by P. E. Cloud, Jr. *Above:* Close view at low tide of irregualr edge of seaward reef margin, showing abrupt drop to depths at right. Brown, rose, and golden *Pocillopora elegans* (Dana) and gold, tan, and pink *Acropora humilis* (Dana) dominate the scene. *Below:* Underwater view of small pinnacle along and joined to the reef front a few feet below the surface. *Pocillopora*, *Acropora*, and (at the top) the hydrozoan *Millepora tenera* Boschma are prominent.



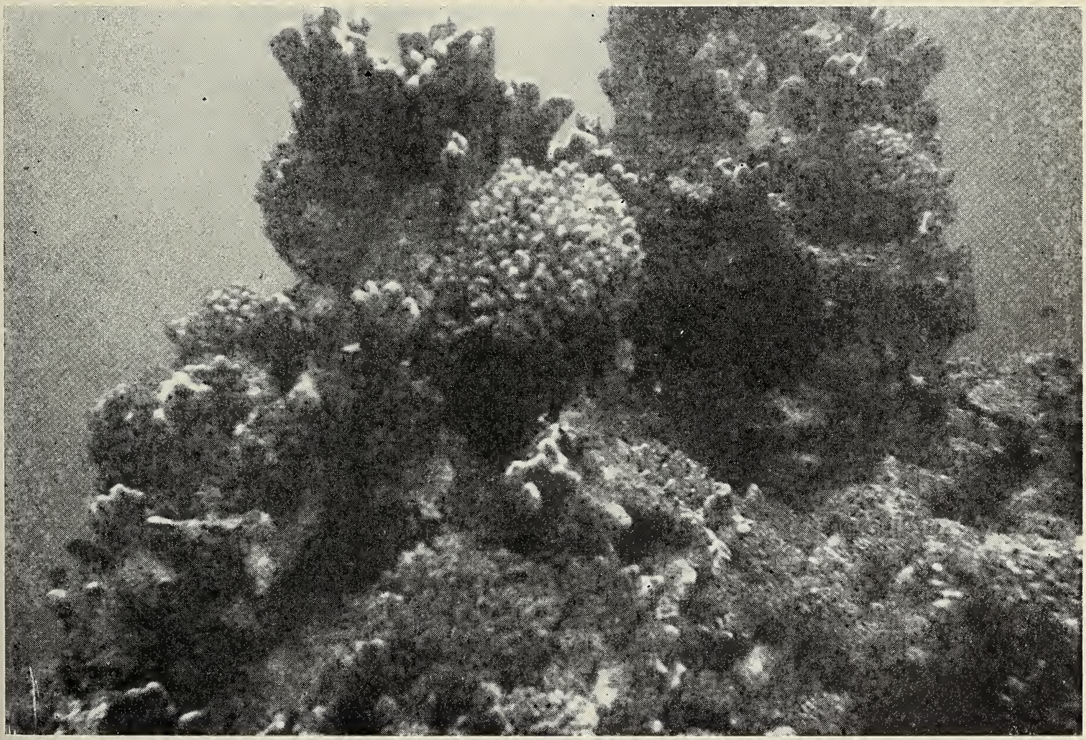


PLATE 2

These geographic ranges are based primarily upon an exhaustive examination of the entire Indo-Pacific collection in the U. S. National Museum. In the interest of accuracy, only records by collectors known to be reliable are included. If a range is represented solely by specimens in the Museum, this fact is indicated by a phrase such as "U. S. N. M. collections are from." If the Museum collections contain but a few specimens of a given species, the specific localities are enumerated.

In order to expand the distributional patterns for many species, dependable published sources were consulted. Unless otherwise specified, the Australian records are based upon Allan (1950), Hawaiian records upon Tinker (1952), records from the Philippines upon Faustino (1928), from "southern Japan" (this term refers to Kyushu Province) and the Ryukyu Islands upon Kuroda and Habe (1952). Formosan records were taken from Kuroda (1941), and records for East Africa, the Seychelles, and Madagascar are from von Martens (1880). Particularly useful in completing the ranges of the Terebridae, Mitridae, and Conidae were the publications of Dautzenberg (1935, 1937). Where the nomenclature of a species is in doubt, only National Museum records are cited, with no reference to published reports.

Each species is described as "common," "fairly common," or "uncommon" in Micronesia, based upon the frequency of its occurrence in the National Museum collections. These terms lack precision but give some indication of relative abundance.

DISCUSSIONS OF THE SPECIES

Family PATELLIDAE—Limpets

Genus PATELLA Linné, 1758

Patella stellaeformis Reeve, 1842.
Hirase and Taki (1951) pl. 57, fig. 2.

Characteristically 1 to 1.25 inches long and bright yellow within.

P. stellaeformis typically is found attached to exposed rocks of intertidal reef flats, frequently nestled in rock crevices. It is found most commonly on seaward reefs along, or just shoreward of, the reef edge, but occasionally it occurs near the edge of lagoon reef flats. Adaptations to its precarious environment are its muscular foot, with which it clings to the rocks, and its streamlined shell, which offers little resistance to the breaking waves. Ordinarily its shell is camouflaged by an overgrowth of coralline algae, vermetids, and other encrustations so that it blends with its similarly encrusted rocky substrate. Like most limpets, *P. stellaeformis* is herbivorous, and uses its radula to scrape algae from the rock surfaces.

GEOGRAPHIC RANGE: USNM collections are from southern Japan, and from the Mariana, Marshall, Gilbert, Caroline, Loyalty, Samoan, Cook, Society, and Tuamotu islands. Reported from Formosa and the Philippines but not from Australia or Hawaii. Common in Micronesia.

Family TROCHIDAE—Top Shells

Genus MONODONTA Lamarck, 1801

Monodonta labio (Linné, 1758).
Hirase and Taki (1951) pl. 66, fig. 8.

Characteristically 1.25 to 1.5 inches long, with purple and black beading and silvery white within the aperture.

The recent Micronesian collections contain only two specimens. Both were found living among intertidal rocks on the beach at Tomil Harbor, Yap.

GEOGRAPHIC RANGE: USNM collections are from the south China coast, southern Japan, the Ryukyu, Philippine, and Caroline islands, Borneo, and northern Australia. Reported from Madagascar but not from Hawaii. Uncommon in Micronesia. *M. labio* apparently is found along continental shores and high islands but not along the shores of atolls.

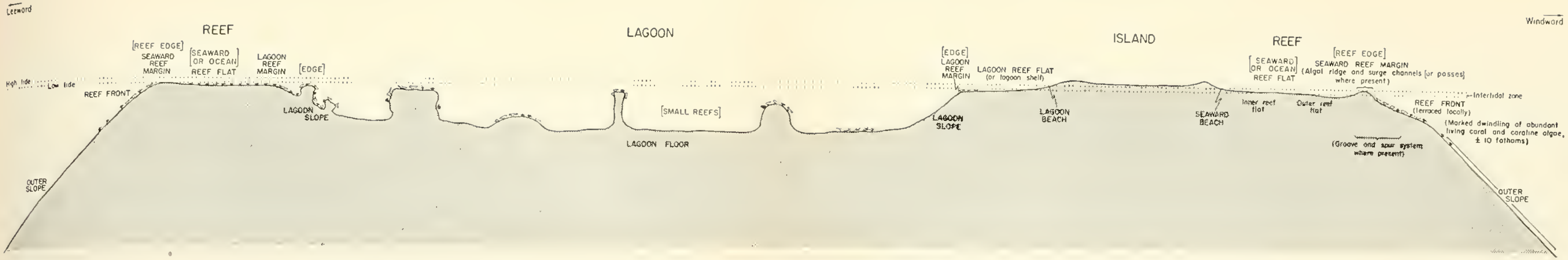


PLATE 3. The conspicuous features of an atoll and its peripheral reef (after Tracey, Cloud, and Emery, 1955). Hypothetical section, not to scale. Principal features are shown in capital letters; other features, subdivisions, and explanatory notes are indicated in lower-case letters. Terms enclosed in brackets are the ones that have been used in this report.

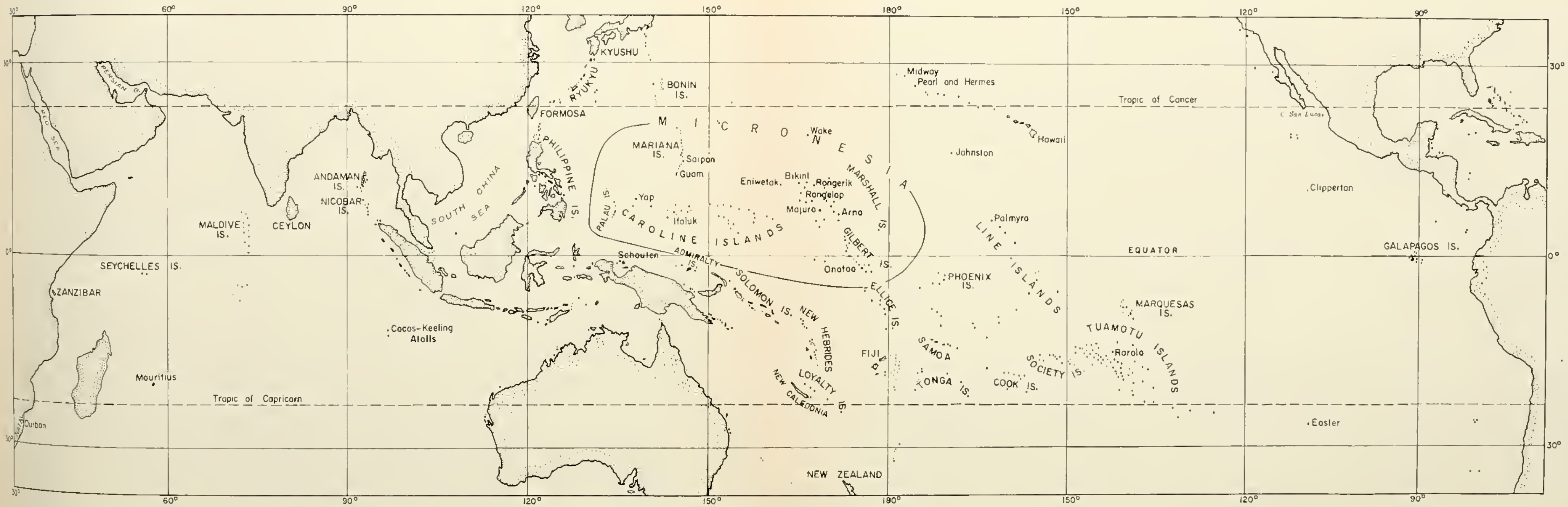


PLATE 4. Index map of the Indo-Pacific Region.

Genus TECTUS Montfort, 1810

Tectus pyramis (Born, 1780) (syn. *obeliscus* Gmelin, 1791; *acutus* Lamarck, 1822; *tabidus* Reeve, 1861).

Hirase and Taki (1951) pl. 65, fig. 8.

Characteristically 2.5 to 3.5 inches long, white or grayish, and possessing a heavy, conspicuous columellar fold.

Ordinarily found in rock crevices near the edge of seaward reef flats, both windward and leeward. Also taken on lagoon reef flats, on minor reef prominences in lagoons, and on coral masses in surge channels along the seaward reef edge. Lives at or near low tide line to depths of 10 feet. Commonly associated with species of *Turbo*, *Vasum*, and *Bursa*.

GEOGRAPHIC RANGE: Widespread and fairly common in Micronesia but not throughout the Indo-Pacific. Not found in Hawaii. US NM records are from southern Japan, the Ryukyu, Philippine, Mariana, Caroline, Marshall, Gilbert, Solomon, Loyalty and Fiji islands, Samoa, and New Caledonia.

Genus TROCHUS Linné, 1758

There are several closely related representatives of this genus in the Indo-Pacific. Extensive study, beyond the scope of this paper, is needed to clarify their systematic positions. As in other groups, the most widely accepted and generally understood names are recorded here.

Trochus histrio histrio Reeve, 1848.

Typically 1 to 1.25 inches long, with a red columellar blotch and a spiral ridge within the columella. Characterized by beading of unequal size, the bead rows immediately above the sutures tending to be larger than the beading on the rest of the shell. The beading in general is finer than that of *T. histrio intextus*.[2]

[2] Unlike *T. histrio histrio*, the Hawaiian form of *Trochus*, *T. histrio intextus* Kiener (1850), possesses evenly spaced, spiral rows of uniformly sized beading over the entire shell. It lives among rocks of seaward reef flats. Morrison found specimens living on the concrete walls at Coconut Island, Kaneohe Bay, Oahu. Apparently it is limited to the Hawaiian Islands.

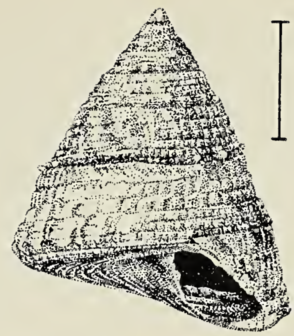


FIG. 1. *Trochus histrio histrio* Reeve. Bikini Atoll, Marshall Islands (USNM 579805).

Commonly found on small reefs on lagoon floors in water 1 to 20 feet deep. Also lives on rocks in the lower intertidal zone of both windward and leeward ocean reef flats, ordinarily on the reef edge.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM collections are from the south China coast, southern Japan, and the Ryukyu, Philippine, Mariana, Palau, Caroline, Marshall, Gilbert, Ellice, and Line (Palmyra) islands. A common Micronesian species, not found in Hawaii.

Trochus maculatus Linné, 1758.

Hirase and Taki (1951) pl. 65, fig. 1.

Characteristically 2 to 2.5 inches long and marked from apex to base with discontinuous longitudinal red streaks. *T. maculatus* lacks the columellar ridge and red columellar blotch of *T. histrio*.

Lives on rocks at the outer edge of both seaward and lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections are from India, the Gulf of Siam, south China coast, southern Japan, from the Ryukyu, Palau, and Philippine islands, and from Arno Atoll. *T. maculatus* is rare in Micronesia, and absent from Hawaii, but it is fairly common in southern Japan and in the Ryukyu and Palau islands.

Trochus niloticus Linné, 1767.

Hirase and Taki (1951) pl. 65, fig. 6.

The largest of the Trochidae, commonly with a basal diameter of 4 or 5 inches and a length of 3 to 4 inches. White with reddish, wavy, interrupted longitudinal streaks.

Ordinarily lives in shallow water on rocks and in crevices near the outer edge of both seaward and lagoon reef flats. Also found on rocky bottoms, both ocean and lagoon, to depths of 40 or 50 feet.

T. niloticus is the object of extensive fisheries in Australia, Japan, the Palau, Philippine, Andaman, and Nicobar islands, because its shell is commercially valuable for manufacturing buttons and jewelry and for inlaying and similar ornamental work. A detailed account of its life history, habits, and habitat is presented by Rao (1939). The commercial use of the shell in the Philippines is discussed by Talavero and Faustino (1931).

GEOGRAPHIC RANGE: USNM collections are from Mauritius eastward to Fiji, and from southern Japan south to New Guinea and New Caledonia. Reported from northern Australia but not from Hawaii. Colonies of *T. niloticus* have been introduced at Truk, Yap, the Palau and Marshall islands.

Trochus ochroleucus Gmelin, 1791.

Characteristically 1.25 to 1.5 inches long. Resembles *T. maculatus* and *T. histrio* but may be recognized by its more massive shell, the short subsutural axial riblets on its body whorl, the raised spiral cord on its columella, and the absence of a red columellar blotch. Specimens are commonly encrusted with coralline algae, vermetids, and Foraminifera.

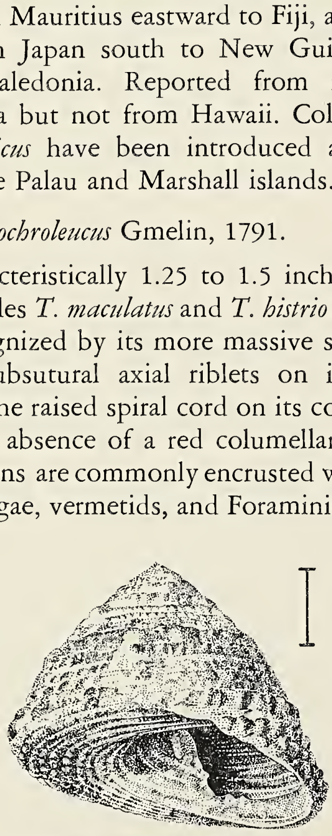


FIG. 2. *Trochus ochroleucus* Gmelin. Kikaigasima, Osumi, Japan (USNM 343138).

Lives under rocks and among coralline algal heads at the edge of reef flats, in the zone of breaking surf. Records in the recent Micronesian collections indicate that *T. ochroleucus* lives in greatest abundance on windward reefs, both ocean and lagoon, although a few specimens were taken from leeward ocean reefs. *T. ochroleucus* is invariably found below low tide line.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM collections are from southern Japan, the Ryukyu, Bonin, Mariana, Caroline, Admiralty, Marshall, Gilbert, Solomon, Loyalty, and Fiji islands, Samoa, Niaufou, and New Guinea. Fairly common in Micronesia. Not found in Hawaii.

Family TURBINIDAE—Turban Shells

Genus TURBO Linné, 1758

Turbo argyrostoma Linné, 1758.
Hirase and Taki (1951) pl. 73, fig. 4.

Characteristically 1.75 to 3.5 inches long. Recognized by its papillose, brownish or greenish operculum and the low scaly spines on its spiral ribs.

T. argyrostoma lives in rock crevices on seaward reef flats, along the seaward reef edge, in rocky passes between reefs, and in crannies on minor reef prominences in lagoons. It invariably occurs below low tide line, commonly in several feet of water.

GEOGRAPHIC RANGE: USNM collections are from Aldabra Island and Mauritius in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands; and from southern Japan, the Ryukyu and Bonin islands south to New Guinea and New Caledonia. Reported to be common in Queensland, Australia. It is the most common *Turbo* in Micronesia.

A form or subspecies of *T. argyrostoma*, characterized by a tendency toward channelled sutures, swollen whorls, and a lack of spines, is common in Hawaii, although typical *T. argyrostoma* is not found there. This

form has been called *T. articulatus* Reeve and *T. intercostalis* Menke.

Turbo petholatus Linné, 1758 (syn. *variabilis* Reeve, 1842; *militaris* Reeve, 1848).
Hirase and Taki (1951) pl. 73, fig. 1.

Characteristically 1.25 to 3 inches long with a polished shell strikingly marked with reddish-brown and fawn color.

The recent Micronesian collections contain only two specimens of *T. petholatus*. Both were found living on small reefs on the sandy lagoon shelf at Ifaluk. These particular reefs are never exposed, even during spring tides, and are ordinarily covered by 3 to 5 feet of water at low tide.

GEOGRAPHIC RANGE: USNM collections are from Mauritius in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands, and from southern Japan south to northern Australia and New Caledonia. Uncommon in Micronesia. Not found in Hawaii.

Turbo setosus Gmelin, 1791 (syn. *stenogyrus* Fischer, 1873).
Hirase and Taki (1951) pl. 73, fig. 5 [as *T. stenogyrus* Fischer]; Morris (1952) p. 164, pl. 35, fig. 11.

Characteristically 1.5 to 3.75 inches long. Distinguished from *T. argyrostoma* by its typically smooth, white operculum, its lower spire, and the absence of spines on its spiral ribs.

T. setosus apparently lives almost exclusively on the seaward edge of windward ocean reef flats, embedded in rock crevices. It is also reported from the edge of the windward lagoon reef flat at Bikini where the lagoon is broad enough to allow the development of a strong surf along the windward lagoon shore.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from the Mariana, Marshall, Gilbert, Caroline, Solomon, Fiji, Samoan, Niaufou, Cook, Society, and Tuamotu islands, and from New Guinea. Reported from the Ryukyus, Philippines, Formosa, and Queensland, Australia. Common in Micronesia but not as abundant there as *T. argyrostoma*. Absent from Hawaii.

Family NERITIDAE—Nerites

Genus NERITA Linné, 1758

Nerita albicilla Linné, 1758.
Hirase and Taki (1951) pl. 75, fig. 8; Morris (1952) p. 166, pl. 36, fig. 15; Kira (1955) pl. 11, fig. 15.

Characteristically about one inch long with rows of tubercles on the columellar deck.

N. albicilla is a solitary species found on or under rocks of seaward reef flats or along rocky ocean shores. None of the specimens studied were taken along lagoon shores. *N. albicilla* apparently lives near low tide line, farther from shore than *N. plicata*, *N. polita*, or *N. undata*.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast, including the Red Sea, eastward through the Indian and Pacific oceans to the Tuamotu Islands, and from southern Japan and Hawaii south to New South Wales, Australia. An uncommon species in Micronesia.

Nerita plicata Linné, 1758.
Hirase and Taki (1951) pl. 75, fig. 14; Tinker (1952) p. 198, figs. on p. 199; Kira (1955) pl. 11, fig. 17.

Characteristically about one inch long with conspicuous raised spiral ribs, a wrinkled columellar deck, and four strong columellar teeth.

N. plicata is typically found living in groups on and under rocks at and above high tide line along both ocean and lagoon shores. Although it is out of water for long periods, it apparently avoids desiccation by remaining in rock crevices during the day. At night it creeps about the rocks, presumably feeding upon surface algae. It is also frequently active on rainy or overcast days. *N. plicata* is commonly associated with species of *Littorina* and *Melampus*.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast, eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands, to Clipperton Island in the eastern Pacific, and from southern Japan and Hawaii south to Queensland, Australia. *N. plicata* is very common throughout the Indo-Pacific.

Nerita polita Linné, 1758.

Hirase and Taki (1951) pl. 75, fig. 13; Morris (1952) p. 165, pl. 36, fig. 16; Kira (1955) pl. 11, fig. 19.

Characteristically about one and one-half inches long, with a smooth, polished shell mottled with grey, white, and black.

N. polita lives among rocks at and above, but generally not below, high tide line along both ocean and lagoon shores. During the day it remains buried about an inch deep in sand between the rocks. At night it browses on the algae-covered rock surfaces.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast, including the Red Sea, eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to the East Indies, New Guinea, and New Caledonia. Reported from northern Australia. Very common throughout the Indo-Pacific.

Nerita signata Lamarck, 1822 (syn. *reticulata* Karsten, 1789, nonbinom.).

Characteristically 1 to 1.25 inches long, with raised spiral ribs crossed by numerous fine, wavy crenulations.

The recent Micronesian collections contain only one individual, found among intertidal rocks of the beach at Tomil Harbor, Yap.

GEOGRAPHIC RANGE: Apparently limited to the Pacific, uncommon in Micronesia, and absent from Hawaii. USNM records are from the Ryukyu Islands, Gulf of Siam, Borneo, and the Philippine, Caroline, Fiji, and Gilbert islands.

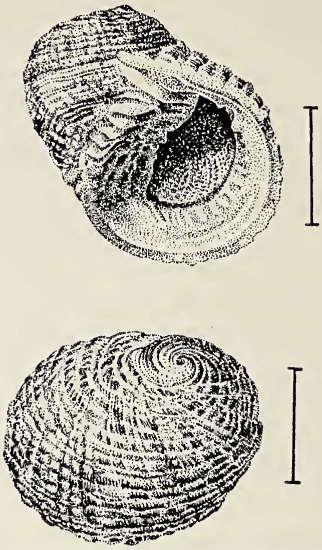


FIG. 3. *Nerita signata* Lamarck. Yap Island, western Carolines (USNM 614206).

Nerita undata Linné, 1758.

Characteristically 1 to 1.5 inches long, blackish with a white columella and aperture, and bearing numerous spiral incised grooves.

Specimens in the collections studied were found on and under rocks at or near high tide line along the tidal flats and rocky beach

FIG. 4. *Nerita undata* Linné. Yap Island, western Carolines (USNM 614207).

at Tomil Harbor, Yap. Morrison reports *N. undata* from the mangrove swamps along Bay of Islands, Fiji, living in the mud or on the mangrove roots together with *Littorina scabra.*

GEOGRAPHIC RANGE: Widespread but apparently limited to the muddy shores of high volcanic islands and continental coasts and not found along the shores of atolls. USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Tuamotu Islands, and from the Ryukyu Islands south to northern Australia and New Zealand. Uncommon in Micronesia and not reported at all from the Marshall, Mariana, Gilbert, or Hawaiian islands.

Family LITTORINIDAE—Periwinkles

Genus LITTORINA Ferussac, 1821

Littorina coccinea (Gmelin, 1791) (syn. *obesa* Sowerby, 1832).

Characteristically 0.5 to slightly more than 1 inch long with a red-brown columella and aperture and without spiral lines within the aperture. Exterior light pink or purplish and entirely lacking additional color markings.

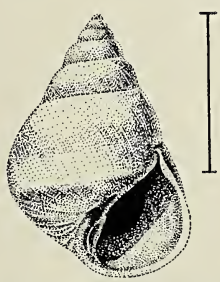


FIG. 5. *Littorina coccinea* (Gmelin). Bikini Atoll, Marshall Islands (USNM 585874).

Lives at and above high tide line along rocky shores, both ocean and lagoon, commonly in groups in rock crevices. Frequently found in the zone barely wet by spray at high tide and even in areas wet only by rain. Morrison reports having found this species living as far as 50 to 100 yards inland. *L. coccinea* is characteristically active at night or on overcast days.

GEOGRAPHIC RANGE: USNM collections are from Cocos-Keeling Atoll in the Indian Ocean eastward to the Hawaiian and Society islands, and from southern Japan south through Micronesia to Fiji. Reported from northern Australia. *L. coccinea* is the most common littorine in Micronesia.

Littorina pintado (Wood, 1828).
Hirase and Taki (1951) pl. 79, fig. 12; Tinker (1952) p. 174, 2 figs. on p. 175 (poor).

Characteristically 0.37 to slightly less than 1 inch long with a dark brown columella and conspicuous dark brown spiral lines within the aperture. Exterior purplish gray and covered with minute streaks or dots.

Habitat similar to that of *L. coccinea*, although *L. pintado* apparently does not live as far above high tide line as does *L. coccinea.* According to Morrison and Cloud, the two species overlap in the upper spray zone, *L. coccinea* extending upward and *L. pintado* extending down. Like most littorines, *L. pintado* can survive long periods of exposure. Edmondson (1946) reports an individual which, after being out of water for nearly a year, revived in a few minutes upon being replaced in sea water.

GEOGRAPHIC RANGE: Uncommon in Micronesia, and apparently limited in its range to the northern Pacific islands. USNM collections are from southern Japan, the Ryukyus, Bonins, Philippines (northern group only), Marianas, Marshalls, Johnston Island, and Hawaii. Reported from Formosa.

Littorina scabra (Linné, 1758).
Hirase and Taki (1951) pl. 79, fig. 13; Tinker (1952) p. 174, 3 figs. on p. 175.

Characteristically 0.5 to slightly more than 1.5 inches long and marked on all whorls with broad, brown zig-zag streaks.

Lives at and above high tide line along muddy mangrove shores, either on the man-

grove roots or in the mud, and also among shoreline rocks. Commonly associated with *Nerita undata*.

GEOGRAPHIC RANGE: Apparently more abundant along continental and high-island shores than on atolls. USNM collections are distributed from East Africa through the Indian and Pacific oceans to Hawaii and Tahiti, and from the Philippines and Marianas south to northern Australia. Reported from the Ryukyu Islands. Uncommon in Micronesia.

Littorina undulata Gray, 1839.
Hirase and Taki (1951) pl. 79, fig. 11; Tinker (1952) p. 174, 2 figs. on p. 175.

Characteristically 0.37 to 0.87 inches long with a purplish columella. Exterior variously marked with brown zig-zag streaks, dots, or indefinite color markings.

Lives near and above high tide line along rocky shores, both ocean and lagoon. Groups of *L. undulata* commonly occur in rock crevices.

GEOGRAPHIC RANGE: USNM collections are from the coast of India, Ceylon, and Cocos-Keeling Atoll eastward to the Line Islands and Samoa, and from southern Japan south to New Guinea and New Caledonia. Reported from Hawaii but not from Australia. Fairly common in Micronesia.

Family CERITHIIDAE—Ceriths

Genus RHINOCLAVIS Swainson, 1840

Rhinoclavis aluco (Linné, 1758).
Hirase and Taki (1951) pl. 83, fig. 7.

Characteristically 2 to 2.5 inches long.

Ordinarily lives on lagoon shelves, buried in sand among roots of turtle grass and other seaweeds, or in sand pockets on or among small lagoon reefs. Invariably found below low tide line, commonly at depths of a few feet.

GEOGRAPHIC RANGE: Apparently limited to the western and west central Pacific, uncommon in Micronesia, and absent from Hawaii. USNM records are from the Ryukyu, Philippine, Palau, Caroline, Solomon, Samoan, and Fiji islands, the Sulu Archipelago, the Schouten Islands off New Guinea, and from northern Australia and New Caledonia.

Rhinoclavis aspera (Linné, 1758).
Hirase and Taki (1951) pl. 83, fig. 1.

Characteristically 1 to 2 inches long.

Ordinarily lives in sand on lagoon floors or off the edge of seaward reefs. Also found in sand pockets on seaward reef flats and on small lagoon reefs. Invariably occurs below low tide line, usually at depths of 3 to 15 fathoms.

GEOGRAPHIC RANGE: USNM collections are from Mauritius and Ceylon eastward throughout the Indian and Pacific oceans to the Cook Islands, and from southern Japan and Palmyra south to northern Australia. Apparently not found in Hawaii, but fairly common in Micronesia.

Rhinoclavis sinensis (Gmelin, 1791) (syn. *obeliscus* Bruguière, 1792).
Hirase and Taki (1951) pl. 83, fig. 4; Tinker (1952) p. 166, 3 figs. on p. 167 [as *C. obeliscus* Bruguière].

Characteristically 1.25 to 2 inches long.

Lives among sand and rocks on seaward reef flats both windward and leeward, and on small reefs of sandy lagoon shelves. Ordinarily found near, or a few feet below, low tide line.

GEOGRAPHIC RANGE: According to USNM records, distributed along the entire east African coast from Natal, Durban, South Africa, to the Red Sea, eastward throughout the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia. A fairly common species in Micronesia.

Rhinoclavis tenuisculpta (Reeve, 1866).

Characteristically 1 to 1.75 inches long and sculptured with nodulose spiral cords, of which 4 or 5 may be heavier than the others. Shell white and typically mottled with brown,

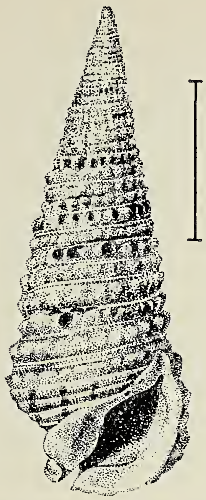


FIG. 6. *Rhinoclavis tenuisculpta* (Reeve). Bikini Atoll, Marshall Islands (USNM 580526).

although entirely white specimens have been found. Aperture white.

Found living in sand on lagoon floors and off the edge of seaward reefs, at depths of 10 to 500 feet.

GEOGRAPHIC RANGE: USNM collections are distributed from Mauritius eastward throughout the Indian and Pacific oceans to Midway Island and the Tuamotus, and from southern Japan south to northern Australia. Fairly common in Micronesia, but apparently replaced in Hawaii by *R. granifera* Pease.

Rhinoclavis vertagus (Linné, 1767).
Hirase and Taki (1951) pl. 83, fig. 2.

Characteristically 1.5 to 2.5 inches long.

The recent Micronesian collections contain only one specimen, found living among intertidal rocks on the beach at Tomil Harbor, Yap.

GEOGRAPHIC RANGE: USNM records are distributed from Mauritius and Ceylon eastward through the Indian and Pacific oceans only as far as the Caroline and Solomon islands, and from the Ryukyu Islands south to northern Australia. An uncommon species in Micronesia. Not found in Hawaii.

Genus CERITHIUM Bruguière, 1789

Cerithium alveolus Hombron and Jacquinot, 1841 (syn. *C. piperitum* Sowerby, 1855).

Characteristically less than one-half inch long. Shell white, covered with spiral ridges of varying depth and with many fine, brown spots. Columella violet. *C. alveolus* superficially resembles *C. sejunctum*, but it is more slender, its brown markings are finer, its spiral ridges are not nodose, and its outer lip is not violet.

The many specimens from the Marshall Islands in the collections studied indicate that *C. alveolus* is abundant on windward ocean reef flats where it lives in sandy depressions among rocks and in rocky tide pools. The collections also include several specimens from the sandy lagoon bottom of Tanapag Harbor, Saipan, found among small reefs at depths of 10 to 15 feet.

GEOGRAPHIC RANGE: USNM records are from the Mariana and Marshall islands only. Reported from the Ryukyu Islands and Formosa, but not from Hawaii. Probably more widespread but rarely noticed because of its small size. Apparently fairly common in Micronesia.

FIG. 7. *Cerithium alveolus* Hombron and Jacquinot. Bikini Atoll, Marshall Islands (USNM 583953).

Cerithium columna Sowerby, 1855 (syn. *echinatum* Kiener, 1841; not Lamarck, 1822).
Tinker (1952) p. 166, 3 figs. on p. 167.

Characteristically 0.75 to 1.5 inches long. Shell whitish. Aperture white. Spiral ridges between the nodes commonly dark brown.

Ordinarily found buried in sand near and below low tide line. Most of the specimens in the recent Micronesian collections were

living in sand pockets on windward ocean reef flats. USNM specimens from Hawaii, however, were dredged from depths of 30 to 300 feet off Honolulu Harbor and Waikiki Beach. *C. columna* is also common in the lagoon at Pulo Panjang, Cocos-Keeling Atoll (Abbott, 1950), and on the reefs of northern Australia (Allan, 1950).

GEOGRAPHIC RANGE: USNM collections are distributed from Mauritius eastward through the Indian and Pacific oceans to the Hawaiian and Tuamotu islands, and from southern Japan south to northern Australia. A common species in Micronesia.

Cerithium morus Bruguière, 1792.

Characteristically about one inch long, rather inflated, and strongly granulose. Shell dark brown or black. Aperture white. The recent Micronesian collections contain only four specimens, all of which were found among intertidal rocks at Tomil Harbor beach, Yap.

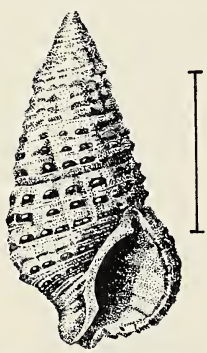


FIG. 8. *Cerithium morus* Bruguière. Guam, Mariana Islands (USNM 585837).

GEOGRAPHIC RANGE: USNM collections are distributed from Mauritius and the east coast of India eastward through the Indian and Pacific oceans to the Hawaiian and Tuamotu islands, and from the Philippine and Mariana islands south to Borneo, the Solomon Islands, and Fiji. Not reported from Australia or southern Japan. Uncommon in Micronesia.

Cerithium nassoides Sowerby, 1855 (syn. *maculosum* Mighels, 1845).

Tinker (1952) p. 170, 2 figs. on p. 171 [as *C. maculosum* Mighels].

Characteristically less than one-half inch long and white with scattered brown spots of varying size.

Only one specimen in the recent Micronesian collections was taken alive. It was found in a sand pocket among small reefs at a depth of 10 to 20 feet in the lagoon entrance west of Saipan. Dead specimens were taken from seaward reef flats at Eniwetok and Rongelap.

GEOGRAPHIC RANGE: Apparently limited to the Pacific and fairly common in Micronesia. USNM records are from the Mariana, Marshall, Loyalty, Tuamotu, and Hawaiian islands only. Reported from southern Japan but not from Australia.

Cerithium nodulosum Bruguière, 1792.

Hirase and Taki (1951) pl. 83, fig. 8; Kira (1955) pl. 12, fig. 22.

The largest Indo-Pacific *Cerithium*, characteristically 3 to 4.5 inches long.

Lives among sand and rocks on seaward reef flats, ordinarily just shoreward of the reef edge. Also found in channels between reef segments and on small lagoon reefs. Invariably occurs below low tide line, commonly in a few feet of water but occasionally at depths of 10 feet or more.

GEOGRAPHIC RANGE: USNM records are distributed from Mauritius eastward throughout the Indian and Pacific oceans to the Society Islands, and from the Ryukyu, Mariana, and Marshall islands south to New Caledonia. Reported from northern Australia but not from southern Japan or Hawaii. Fairly common in Micronesia.

Cerithium salebrosum Sowerby, 1855.

Characteristically one inch or less long, slender and sharply sculptured with strong axial ribs crossed by spiral cords. Shell and aperture white. Ordinarily lives on sandy lagoon slopes and floors at depths of about 5 to 200 feet. Occasionally taken on small reefs of sandy lagoon. Apparently not found on seaward reef flats or above low tide line.

FIG. 9. *Cerithium salebrosum* Sowerby. Ifaluk Atoll, Caroline Islands (USNM 614197).

GEOGRAPHIC RANGE: USNM records are exclusively from atolls in the Caroline, Marshall, and Gilbert islands. Appears to be uncommon in Micronesia, and absent from Hawaii, but is probably more widespread than the records indicate, being rarely noted because of its small size and relatively deep water habitat.

Cerithium sejunctum Iredale, 1929 (syn. *variegatum* Quoy and Gaimard, 1834, preocc.).

FIG. 10. *Cerithium sejunctum* Iredale. Bikini Atoll, Marshall Islands (USNM 580070).

Characteristically about one-half inch or less in length and with granose spiral ridges. Shell whitish, mottled with varying shades of brown. Aperture typically pale violet, particularly on the columella and outer lip. Ordinarily found buried in sand near or a few feet below low tide line. Most of the specimens in the recent Micronesian collections were living in sand among rocks and in rocky tide pools on windward ocean reef flats. Abbott (1950) reports *C. sejunctum* to be "plentiful in the lagoon in shallow, weedy water" at Cocos-Keeling Atoll.

GEOGRAPHIC RANGE: USNM records are from Cocos-Keeling Atoll in the Indian Ocean and from the Marshall, Gilbert, Phoenix, and Fiji islands in the Pacific. Reported from southern Japan and Formosa, but not from Hawaii. Common in Micronesia.

Cerithium tuberculiferum Pease, 1869.
Tinker (1952) p. 166, 2 figs. on p. 167 [as *C. echinatum* Lamarck].

Characteristically 1.5 to 2.25 inches long and sculptured with spiral, tuberculated cords which are spinose around the periphery of each whorl. Shell whitish with irregular brown markings. Aperture white.

Found buried in sand among rocks and coral patches below low tide line on seaward and lagoon reef flats and at depths of a few feet in channels between reefs.

GEOGRAPHIC RANGE: USNM records are from the Philippine, Mariana, Marshall, Gilbert, Loyalty, Samoan, Society, Tuamotu, Phoenix, Line, and Hawaiian islands. Not reported from southern Japan or Australia, but fairly common in Micronesia.

Family HIPPONICIDAE—Hoof Shells

Genus HIPPONIX Defrance, 1819

Subgenus SABIA Gray, 1847

Hipponix (*Sabia*) *conicus* (Schumacher, 1817).

Characteristically 0.25 to 0.75 inch long, with irregular radial ribs, and white with a dark brown muscle scar inside the shell. Commonly lives below low tide line on seaward reef flats, attached to the shells of other gastropods, typically around the aperture. A species with similar attachment habits (*H. australis*) has been observed by Risbec (Yonge, 1953) to feed upon the fecal pellets of the host. Specimens in the present collections were found on *Turbo setosus*, etc. Morrison and Cloud report a possibly unrecorded species of *Hipponix* which they found in Micronesia attached to corals, algae, or rocks; they believe it feeds on detritus, as does the common California *H. antiquatus* (Yonge, 1953). Specimens in the present collections were found on *Turbo setosus* and *T. argyrostomus*, *Vasum turbinellue* and *V. ceramicum*, *Thais ar-*

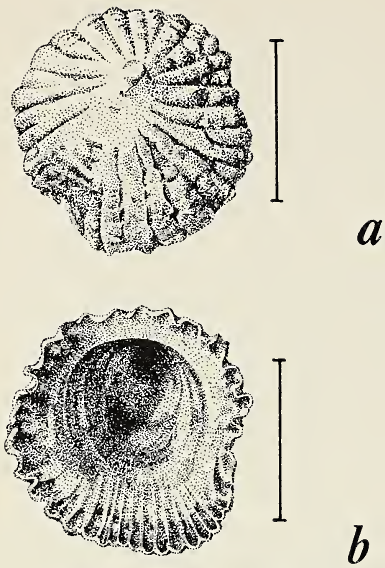


FIG. 11. *Hipponix* (*Sabia*) *conicus* (Schumacher). *a*, exterior view of specimen from Pavuvu, Solomon Islands (USNM 488419); *b*, interior view of specimen from Ifaluk Atoll, Caroline Islands (USNM 614198).

migera, *Drupa morum* and *D. rubusidaeus*, *Morula elata*, *Cerithium tuberculatum* and *C. nodulosum*, and on *Conus distans*, *C. flavidus*, *C. lividus*, and *C. aulicus*. A species with similar attachment habits (*H. australis*) has been observed by Risbec (Yonge, 1953) to feed upon the faecal pellets of the host shell. Micronesian specimens of *Hipponix* found attached to corals, algae, or rocks (Morrison, Cloud) probably feed on detritus, as does the common Californian *H. antiquatus* (Yonge, 1953), and may represent an unrecorded species.

GEOGRAPHIC RANGE: USNM records are from East Africa throughout the Indian and Pacific oceans to the Hawaiian, Tuamotu, and Society islands, and from southern Japan south to northern Australia and New Caledonia. Common in Micronesia.

Genus CHEILEA Modeer, 1793

Cheilea equestris (Linné, 1758).

Tinker (1952) p. 182, fig. on p. 183 (as *C. dillwyni* (Gray)); Kira (1955) pl. 13, fig. 9 (as *C. scutulum* (Reeve)).

Characteristically 1.25 to 1.5 inches long, yellowish white externally and polished white within. Lives among rocks on both seaward and lagoon reef flats, ordinarily a few feet below low tide line.

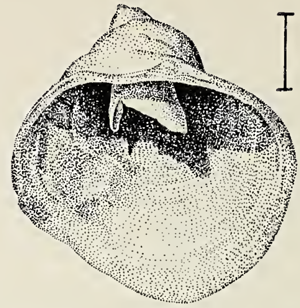


FIG. 12. *Cheilea equestris* (Linné). Onotoa Atoll, Gilbert Islands (USNM 607768).

GEOGRAPHIC RANGE: USNM collections are from the Caroline, Marshall and Gilbert islands and indicate the species to be fairly common in Micronesia. It is reported from southern Japan and Hawaii.

Family STROMBIDAE—Conch Shells

Genus STROMBUS Linné, 1758

Strombus dentatus Linné, 1758 (syn. *tridentatus* Gmelin, 1791).

Tinker (1952) p. 164, 3 figs. on p. 165 [as *S. tridentatus* Lamarck]; Kira (1955) pl. 15, fig. 3 [as *Canarium tridentatum* (Gmelin)].

Characteristically 1.5 to 2 inches long. Shell whitish, mottled with yellow or brown, and with transverse raised ridges on all whorls. Interior of aperture dark orange-brown. Outer lip ridged internally, flared, and bearing several, large white teeth on its outer edge.

Only one specimen in the recent Micronesian collections was taken alive, from under rocks in 3 to 4 feet of water on the sandy lagoon shelf at Ifaluk. Several beach-worn specimens were collected at Eniwetok and Bikini, among rocks on both seaward and lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections are from East Africa, the Red Sea, and Mauritius eastward through the Pacific to the Tuamotu Islands, and from southern Japan and

Hawaii south to New Guinea, the Solomon Islands and New Caledonia. Uncommon in Micronesia.

Strombus fragilis (Röding, 1798) (syn. *samar* Dillwyn, 1817; *bulbulus* Sowerby, 1842).

Characteristically 1.5 to 2 inches long. Shell whitish and mottled with orange or brown. Columella and outer lip reddish-brown. Whorls smooth, lacking the raised ridges of *S. dentatus*. Outer lip flared and ridged internally but without the toothed edge of *S. dentatus*.

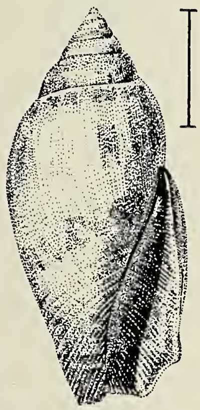


FIG. 13. *Strombus fragilis* (Röding). Guam, Mariana Islands (USNM 533081).

Apparently lives below low tide line in both lagoon and offshore ocean waters. The recent Micronesian collections include only broken specimens dredged from a depth of 150 to 200 feet off the sandy floor of Bikini lagoon, and worn specimens from four feet of water at Yap and from the shore of Mañagaha Island, Saipan.

GEOGRAPHIC RANGE: USNM records are from the Philippine, Mariana, Marshall, Caroline, Samoan, and Fiji islands only. These collections indicate that *S. fragilis* is uncommon in Micronesia and absent from Hawaii.

Strombus gibberulus Linné, 1758.
Kira (1955) pl. 15, fig. 7.

Characteristically 1 to 1.5 inches long and porcelain white with brown markings and a purple or pink aperture.

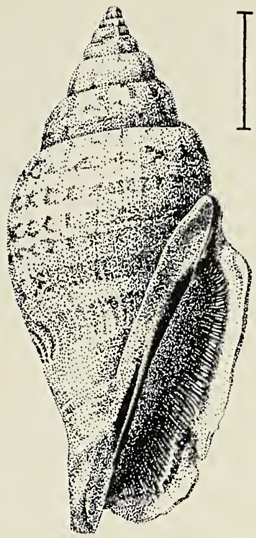


FIG. 14. *Strombus gibberulus* Linné. Yap, Caroline Islands (USNM 614208).

Plentiful in Micronesia on sandy lagoon flats, which are barely exposed at low tide, and on sandy lagoon floors to depths of 60 feet. Also found in sandy depressions on lagoon reef flats. Abbott (1950) reports that *S. gibberulus* is "fairly abundant" on the outer beaches of Cocos-Keeling Atoll. Abbott (1949) also reports the occurrence of thousands of individuals on the sand-mud flats at Guam and describes the habits of this species.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast and the Red Sea eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from the Ryukyu and Hawaiian islands south to Queensland, Australia, and New Caledonia. Common in Micronesia.

Strombus lentiginosus Linné, 1758.
Hirase and Taki (1951) pl. 86, fig. 4; Kira (1955) pl. 16, fig. 8.

Characteristically about three inches long with a silvery pink aperture.

Ordinarily found buried in sand at depths of 4 to 12 feet in quiet waters. Specimens in the recent Micronesian collections were taken on the sandy lagoon shelf at Rongelap and Ifaluk and from a protected channel at Ifaluk.

Abbott (1950) reports that *S. lentiginosus* occurs on the outer beach at Cocos-Keeling Atoll.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to Samoa, and from the Ryukyu, Mariana, and Marshall islands south to New Guinea and New Caledonia. Reported from the Great Barrier Reef, Australia, but not from Hawaii. Common in Micronesia.

Strombus luhuanus Linné, 1758.
Hirase and Taki (1951) pl. 86, fig. 14; Kira (1955) pl. 15, fig. 8.

Characteristically about two inches long with a bright orange-red aperture and black parietal wall.

Lives in sand and coral rubble on lagoon shelves at depths of 2 to 12 feet.

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Persian Gulf eastward through the Indian and Pacific oceans to the Society Islands, and from southern Japan, the Mariana, and Line islands south to New Caledonia and New South Wales, Australia. The National Museum has specimens of *S. luhuanus* from Palmyra, but none from Hawaii. The species is fairly common in Micronesia.

Strombus maculatus Sowerby, 1842.
Tinker (1952) p. 164, 3 figs. on p. 165; Morris (1952) p. 178, pl. 37, fig. 18, col. pl. 8, fig. 13.

Characteristically 0.75 to 1 inch long and whitish with yellowish-brown markings and a white aperture.

Found in sandy gravel between the rocks of seaward reef flats.

GEOGRAPHIC RANGE: USNM records are from the Mariana, Caroline, Marshall, Gilbert, Phoenix, Line (Palmyra), Hawaiian, Cook, and Tuamotu islands, and from Easter Island. Uncommon in Micronesia, although abundant in Hawaii.

Strombus mutabilis Swainson, 1821 (syn. *floridus* Lamarck, 1822).

Characteristically slightly more than one inch long and variable in color. Typically whitish with brown markings and a flesh-colored aperture.

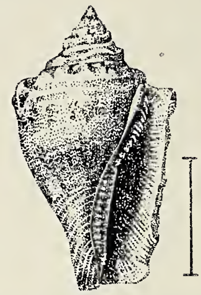


FIG. 15. *Strombus mutabilis* Swainson. Saipan, Mariana Islands (USNM 607947).

Ordinarily lives buried in the sand of lagoon shelves and slopes, among seaweed, from a few feet below low tide line to depths of 15 feet. Also found buried in sand pockets on small lagoon reefs and on seaward reef flats. At Ifaluk, individuals were found in the sandy-muddy sediments of the lagoon shelf among turtle grass roots in 2 to 6 feet of water, in the sandy lagoon floor among algae (*Halimeda* sp.) at depths of 10 to 15 feet, and in sand on lagoon small reefs. At Bikini and Eniwetok specimens were collected from sand on the shallow seaward reef flats. Specimens were also found at Saipan buried among seaweed on the sandy lagoon bottom of Tanapag Harbor at depths of 5 to 15 feet.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast and the Red Sea eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan, the Mariana and Marshall islands, south to northern Australia and New Caledonia. *S. mutabilis* is common in Micronesia, but apparently does not reach Hawaii, where the closely related *S. maculatus* is abundant.

Genus LAMBIS Röding, 1798
(Syn. PTEROCERA Lamarck, 1799)

Lambis chiragra (Linné, 1758).
Hirase and Taki (1951) pl. 88, fig. 2; Kira (1955) pl. 16, fig. 12.

Characteristically 8 to 10 inches long, with a wrinkled, orange-colored aperture and columella.

Lives on seaward reef flats, in sand between rocks and coral heads, and in tide pools. Also found among masses of coral (*Heliopora*) in channels between seaward reefs in 8 to 10 feet of water. Invariably found below low tide line.

GEOGRAPHIC RANGE: USNM collections are from Zanzibar on the east African coast eastward throughout the Indian and Pacific oceans to the Marshall and Gilbert islands, and from southern Japan and the Mariana Islands south to northern Australia and New Caledonia. A common *Lambis* in Micronesia, but not reported from Hawaii.

Lambis lambis (Linné, 1758).
Hirase and Taki (1951) pl. 87, fig. 1; Kira (1955) pl. 16, fig. 7.

Characteristically 6 to 8 inches long with slender, upward-curving apertural spines and a smooth, pinkish aperture.

Lives in sand on both seaward and lagoon reef flats, and on sandy lagoon floors, ranging from a few feet below low tide line to depths of 10 feet.

GEOGRAPHIC RANGE: USNM collections are from the east African coast eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan, the Mariana and Marshall islands south to northern Australia and New Caledonia. The most common Indo-Pacific *Lambis*, but not reported from Hawaii.

Lambis truncata (Humphrey, 1786) (syn. *bryonia* Gmelin, 1791).
Hirase and Taki (1951) pl. 87, fig. 2.

The largest species of *Lambis*, characteristically 10 to 15 inches long. A ponderous shell with a smooth, flesh-colored aperture.

Commonly found at depths of 15 to 30 feet off the edge of seaward reefs, in sand among coral boulders. Also lives on sandy lagoon shelves among seaweed or on minor reef prominences in 2 to 10 feet of water. Invariably occurs below low tide line. At Onotoa Cloud observed a group of individuals which appeared to be sedentary. They were partly buried in the sandy bottom; their shells were overgrown with coral-algal encrustations and with colonies of branching coral 5 to 7 inches high. An examination of their stomach contents indicated that they had ingested quantities of the sandy substrate, presumably for nourishment.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward throughout the Indian and Pacific oceans to the Fiji Islands, and from the Ryukyu, Mariana, and Marshall islands south to New Caledonia. Reported from northern Australia but not from Hawaii. Fairly abundant in Micronesia.

Genus TEREBELLUM Lamarck, 1799

Terebellum terebellum (Linné, 1758) (syn. *subulatum* Lamarck, 1811).
Hirase and Taki (1951) pl. 89, fig. 1; Kira (1955) pl. 15, fig. 1.

Characteristically 2 to 3 inches long and whitish with light brown markings.

The recent Micronesian collections include several lots of this species dredged from depths of 90 to 200 feet on the sandy bottom of Bikini lagoon and from 6 feet of water in Tomil Harbor, Yap.

GEOGRAPHIC RANGE: There are no USNM records east of Micronesia. USNM collections are from Mauritius in the Indian Ocean eastward through the Pacific to Samoa, and from southern Japan, the Mariana and Marshall islands south to northern Australia and New Caledonia. This species is uncommon in Micronesia.

Family NATICIDAE—Moon Shells

Genus POLINICES Montfort, 1810

Polinices mammilla (Linné, 1758) (syn. *pyriformis* Récluz, 1844).
Hirase and Taki (1951) pl. 91, fig. 4 [as *P. pyriformis* Récluz]; Tinker (1952) p. 188, 3 figs. on p. 189; Morris (1952) p. 174, pl. 37, fig. 8 [as *P. pyriformis* Récluz]; Kira (1955) pl. 17, fig. 10 [as *P. pyriformis* (Récluz)].

Characteristically 1.25 to 2 inches long with an entirely white polished shell.

Although *P. mammilla* is common in Micronesia, only one specimen in the recent collections was taken alive. It was found at night by Cloud on the surface of sandy intertidal flats along the lagoon shore of Uliga Island, Majuro Atoll. Edmondson (1946) reports this species living in Hawaii at depths of a few fathoms and occasionally occurring on the reefs.

GEOGRAPHIC RANGE: USNM collections are from the entire east African coast from Natal, Durban, South Africa, to the Red Sea, eastward through the Indian and Pacific oceans to Samoa, and from southern Japan and Hawaii south to northeastern Australia and New Caledonia.

Polinices melanostoma (Gmelin, 1791) (syn. *opacus* Récluz, 1851).
Hirase and Taki (1951) pl. 91, fig. 1 [as *P. opacus* Récluz].

Characteristically 1.25 to 2 inches long, with a polished white shell and a dark brown inner lip.

Ordinarily found buried in the sand of lagoon shelves or in sand pockets on both seaward and lagoon reef flats, covered by several feet of water. Also lives in sand flats exposed at low tide. Presumably preys on pelecypods.

GEOGRAPHIC RANGE: USNM collections are distributed from East Africa and Mauritius through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Palmyra south to New Guinea and New Caledonia. Fairly common in Micronesia. Reported from Hawaii but not from Australia.

Genus NATICA Scopoli, 1777

Natica marochiensis (Gmelin, 1791).
Morris (1952) p. 174, pl. 37, fig. 5.

Characteristically about three-fourths inch long, with a smooth white calcareous operculum.

N. marochiensis lives on a sandy bottom, ordinarily in shallow water on lagoon shelves or in sand pockets on lagoon reef flats, but it also occurs in protected bays and harbors to depths as great as 50 feet. Typically, it remains buried in the sand during the day and emerges at night.

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Red Sea eastward through the Indian and Pacific oceans to the Cook Islands, and from the Ryukyu and Hawaiian islands south to the Caroline Islands and Samoa. Not reported from Australia. Apparently uncommon in Micronesia, although common at Cocos-Keeling Atoll and in Hawaii.

Natica onca (Röding, 1798) (syn. *chinensis* Lamarck, 1816).
Hirase and Taki (1951) pl. 90, fig. 8; Kira (1955) pl. 17, fig. 4.

Characteristically 0.75 to 1 inch long with raised ridges on its white calcareous operculum. Resembles *N. violacea*, but its umbilicus is more open above and below than is that of *N. violacea;* its callus is white; and its color pattern is in discrete spots only, in rows.

The recent Micronesian collections include only one specimen, an empty shell from 4 feet of water at Yap.

GEOGRAPHIC RANGE: The only USNM specimens are from Okinawa, the Philippines, New Guinea, Admiralty and Solomon islands, New Caledonia, and from Vitilevu, Fiji. Reported from northern Australia, but not from Hawaii. These records indicate *N. onca* may be found only along the shores of high islands and continents but not near atolls. Apparently uncommon in Micronesia.

Natica violacea Sowerby, 1825.
Hirase and Taki (1951) pl. 90, fig. 9.

Characteristically 0.75 to 1 inch long. Resembles *N. onca* but, unlike that species, its umbilicus is rosy or violet and almost entirely covers the umbilicus; and the upper rows of color spots on its shell are larger than those of *N. onca*, and irregular, sometimes "literate" as in variations of *Conus ebraeus*.

Lives on sandy lagoon floors at depths of 90 to 150 feet. Drift specimens found on the seaward beaches of Bikini and Rongelap indicate the species may also live in deep water off the seaward reef edge.

GEOGRAPHIC RANGE: There are only 6 specimens in the USNM, from the northern Marshalls (Bikini and Rongelap atolls) and from Biak, Schouten Islands, Dutch New Guinea. *N. violacea* is rare in collections from Micronesia and the Indo-Pacific.

Family OVULIDAE—Egg Shells

Genus OVULA Bruguière, 1789

Ovula ovum (Linné, 1758).
Hirase and Taki (1951) pl. 94, fig. 18; Kira (1955) pl. 18, fig. 15.

The shell of *O. ovum* is globose and large, characteristically 3 to 5 inches long, polished white externally and deep orange-brown within the aperture. Its mantle, in striking contrast to the white shell, is ink black with only tiny white flecks.

This well-known Indo-Pacific species is prized by island natives for charms and ornaments but is seldom taken alive by collectors. A group of living specimens was found at a depth of about 12 feet in a protected embayment of the seaward reef front at the south side of Arno Atoll. The species was rare at Ifaluk; only one specimen was taken there, at a depth of 3 to 5 feet on the sandy lagoon shelf. At Arno, *O. ovum* was living on the compact surfaces of a dark brown soft coral which turns white where bruised; this association appeared to be a protective one for the mollusk, due to its dark mantle with white spots. However, in the case of the Ifaluk specimen of *O. ovum*, although it was living on a soft coral, that soft coral was presumably a different species, being pale in color and thus affording no color protection for the mollusk. Apparently *O. ovum* is nutritionally dependent upon these alcyonarians.

GEOGRAPHIC RANGE: USNM collections are from East Africa and Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from the Ryukyu Islands south to New Guinea and New Caledonia. Reportedly abundant in northern Australia. Not found in Hawaii.

Family CYPRAEIDAE—Cowries

Genus CYPRAEA Linné, 1758

Subgenus CYPRAEA Linné, 1758

Cypraea (Cypraea) carneola Linné, 1758.
Tinker (1952) p. 142, 3 figs. on p. 143; Morris (1952) p. 180, pl. 5, fig. 11.

Characteristically 1.5 to 2 inches long with bright purple teeth and interstices, four dark orange dorsal bands, and fawn-colored margins. Giant specimens, 2.5 to 3.5 inches long, occur in Hawaii.

Only one specimen in the recent Micronesian collections was taken alive. It was found on a small reef in 2 to 4 feet of water on the sandy lagoon shelf at Ifaluk. Abbott (1950) reports that *C. carneola* lives under rocks in shallow water on the reefs at Cocos-Keeling Atoll. In Hawaii, Ostergaard (1950) found this species in shallow water on seaward reef flats and Ingram (1947) observed giant individuals living in the same environment and copulating with normal-sized *C. carneola*. Like most cowries *C. carneola* is presumably nocturnal.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern Australia, Fiji, and Samoa. A fairly common species in Micronesia.

Cypraea (Cypraea) lynx Linné, 1758.
Tinker (1952) p. 148, 3 figs. on p. 149.

Characteristically about two inches long with many dorsal brownish spots and with bright orange interstices between its white teeth.

Ordinarily found in shallow water, under rocks and in tide pools, on seaward and lagoon reef flats. Also taken from minor reef prominences on sandy lagoon shelves at depths of a few feet.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia. Ingram (1947) reports *C. lynx* to be extremely rare in Hawaii, but it is fairly common in Micronesia.

Cypraea (*Cypraea*) *tigris* Linné, 1758.
Tinker (1952) p. 138, 4 figs. on p. 139; Hirase and Taki (1951) pl. 92, fig. 6; Kira (1955) pl. 20, figs. 16 and 17.

Characteristically 4 to 5 inches long; cream colored or yellowish-white, with large black spots.

C. tigris apparently lives under a variety of ecological conditions, and its size and color pattern differ from one geographic area to another. Records in the recent Micronesian collections indicate that the species most commonly occurs among rocks and in crevices of seaward reef flats, and at the seaward reef edge, near or a few feet below low tide line. Most of the specimens were taken on windward ocean reefs, but the species was also found on leeward ocean reefs, on lagoon reef flats, and on small reefs on lagoon floors. At Tanganyika, East Africa, Abbott (1951) observed a colony of 100 or more *C. tigris* living among eelgrass on a shallow sandy bottom. Few of these individuals were more than two and one-half inches long, and most of them possessed very dark coloring. Abbott also reports similar groups of small individuals from Okinawa, northeast Australia, and Halmahera, Dutch East Indies. In Hawaii, *C. tigris* lives at depths of 6 to 12 feet in offshore ocean waters. Specimens of maximum size are found in Hawaii, but the species is rare there as compared with its occurrences to the south and west.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society Islands, and from the Ryukyu and Hawaiian islands south to northern Australia and New Caledonia. Reported from southern Japan. Common in Micronesia.

Cypraea (*Cypraea*) *vitellus* Linné, 1758.
Hirase and Taki (1951) pl. 92, fig. 4; Tinker (1952) p. 142, 3 figs. on p. 143; Kira (1955) pl. 20, fig. 7.

Characteristically about 2.5 to 3 inches long with variously sized white spots over its fawn-colored dorsum and with thin lines of sand colored specks on its margins.

Apparently lives on rocky surfaces or among rocks at depths of not more than a few feet on the outer flats of both seaward and lagoon reefs. In addition to several beach-worn shells, recent Micronesian collections include only three specimens that were taken alive; one in about three feet of water under rocks on the sandy lagoon shelf at Ifaluk, another on the seaward reef flat of windward Onotoa, and the third under near-shore rocks on the lagoon reef at Ine Village, Arno. Abbott (1950) reports *C. vitellus* living under boulders on the outer barrier reef at Cocos-Keeling Atoll. According to Allan (1950) this species is very common on rocky seaward reefs below low tide line in Australia.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern New South Wales, Australia, and New Caledonia. Uncommon in Micronesia.

Subgenus MAURITIA Troschel, 1863

Cypraea (*Mauritia*) *arabica* Linné, 1758.
Tinker (1952) p. 140, 3 figs. on p. 141.

Characteristically 2.5 to 3 inches long with reddish-brown teeth, a calloused spire, and numerous dark brown longitudinal hieroglyphic streaks over its dorsum.

C. arabica is ordinarily collected among rocks in shallow water on both seaward and lagoon reef flats. The recent Micronesian collections include two specimens that were taken alive, both from seaward reef flats at Ifaluk; one on the outer reef flat just shoreward of the reef edge, the other in a tide pool on the inner reef flat. Hiatt reports *C. arabica* to be the most common *Cypraea* on the shoreward portion of the lagoon reef flat at Ine Village, Arno.

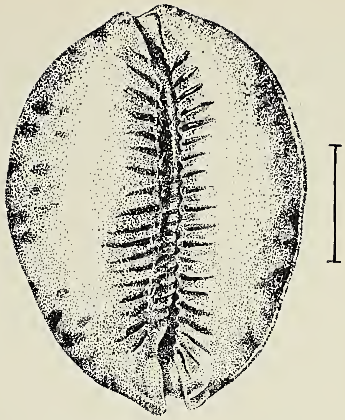
GEOGRAPHIC RANGE: USNM collections are from East Africa and the coast of India eastward through the Indian and Pacific oceans to the Society Islands, and from the Ryukyu and Line islands south to northern New South Wales, Australia, and New Caledonia. Reported from southern Japan but not from Hawaii. Common in Micronesia.

Cypraea (*Mauritia*) *depressa* Gray, 1824.

Characteristically 1.5 to 2 inches long. Like *C. maculifera*, this species has brown dorsal reticulations and brown teeth, but it lacks a brown splotch on its ventral columellar surface.

C. depressa apparently lives under rocks on windward and leeward ocean reef flats, commonly just shoreward of the reef edge. Although a common species in Micronesia, it is seldom collected alive.

GEOGRAPHIC RANGE: USNM records are from Cocos-Keeling Atoll in the Indian Ocean, and from the Palau, Mariana, Caroline, Marshall, Gilbert, Phoenix, Line, Samoan, Cook, Society, and Tuamotu islands. Reported from the Ryukyu Islands, but not from Hawaii. *C. depressa* also ranges far into the eastern Pacific, occurring at Clipperton Island (Hertlein and Emerson, 1953) and at Cocos and the Galapagos islands (Ingram, 1951), but it is not found on the west coast of the Americas.



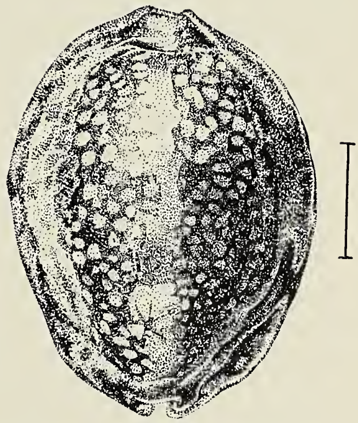


FIG. 16. *Cypraea* (*Mauritia*) *depressa* Gray. Onotoa Atoll, Gilbert Islands (USNM 607761).

Cypraea (*Mauritia*) *maculifera* (Schilder, 1932) (syn. *reticulata* Martyn, 1786, nonbinom.). Tinker (1952) p. 140, 3 figs. on p. 141 [as *C. reticulata* Martyn]; Morris (1952) p. 179, col. pl. 5, fig. 15 [as *C. reticulata* Martyn].

Characteristically 2 to 2.5 inches long with brown teeth and brown dorsal reticulations. Closely resembles *C. depressa* but may be distinguished from that species by the dark brown splotch on its ventral columellar surface.

Ordinarily collected under rocks and loose coral below low tide line on windward ocean reef flats, commonly just shoreward of the reef edge. One specimen in the collections studied was taken from a small reef at a depth

of 4 to 10 feet in the lagoon west of Saipan.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM collections are from the Philippine, Mariana, Caroline, Marshall, Samoan, Cook, Society, Line (Palmyra), and Hawaiian islands.

Cypraea (*Mauritia*) *mauritiana* Linné, 1758.
Tinker (1952) p. 140, 3 figs. on p. 141; Morris (1952) p. 179, pl. 5, fig. 13; Kira (1955) pl. 20, fig. 12.

A large species, characteristically 3.5 to 4 inches long with brown dorsal reticulations and blackish-brown angular margins.

Ordinarily found under rocks or in rock crevices on windward ocean reef flats, commonly just shoreward of the reef edge where the surf is strong. Also taken from the fronts of both windward and leeward reefs, the walls of surge channels in the reef edge, in shallow water on small lagoon reefs, on lagoon reef flats, and along rocky shores. Characteristically lives below low tide line, but also occurs intertidally in moist rock crevices and tide pools. Ingram (1947) collected immature specimens from a pool on a ledge of lava near Hanauma Bay, Oahu. The pool was about 15 feet above the breaking surf at high tide and was sprayed by waves only during high water. Ingram also observed that individuals of the same size ordinarily live together under similar environmental conditions. This species is nocturnal.

GEOGRAPHIC RANGE: USNM collections are from Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society, Tuamotu, and Hawaiian islands, and from southern Japan south to New Guinea and New Caledonia. Allan (1950) reports *C. mauritiana* to be "fairly common" on the Great Barrier Reef of Australia. It is common in Micronesia.

Subgenus EROSARIA Troschel, 1863

Cypraea (*Erosaria*) *caputserpentis* Linné, 1758.
Tinker (1952) p. 156, 3 figs. on p. 157; Morris (1952) p. 179, pl. 5, fig. 2; Kira (1955) pl. 19, fig. 24.

Characteristically 1.25 to 1.5 inches long with brown reticulations over a white dorsum, angular brown margins with white or grayish extremities, and white teeth with brown interstices.

In Micronesia, *C. caputserpentis* is apparently most abundant among rocks on windward ocean reef flats, just shoreward of the reef edge. It is also found on the walls of surge channels along the seaward reef edge, on leeward ocean reefs, on lagoon reef flats, and on small lagoon reefs. It ordinarily lives in shallow water below low tide line but also occurs intertidally in moist rock crevices and in tide pools. Ostergaard (1950) reports that in Hawaii, large numbers of this species commonly occur together on shore rocks washed by the surf at high tide.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands, and from southern Japan, the Hawaiian and Line islands south to northern Australia and New Caledonia. A very common species throughout the Indo-Pacific. A form or subspecies of *C. caputserpentis* is found at Easter Island in the eastern Pacific.

Cypraea (*Erosaria*) *erosa* Linné, 1758.
Tinker (1952) p. 148, 3 figs. on p. 149; Kira (1955) pl. 19, fig. 25.

Characteristically about 1.5 to 2 inches long, with thickened, pitted margins and extremities which are white with brown ridges. Each margin is medially marked with a large, squarish, purple-brown splotch.

Lives among rocks and coral heads just below low tide line on the outer parts of both seaward and lagoon reefs. Abbott (1950) reports three living specimens from pools on the outer reef of Cocos-Keeling Atoll.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society and Tua-

motu islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia. Fairly common in Micronesia.

Cypraea (Erosaria) helvola Linné, 1758.
Tinker (1952) p. 152, 4 figs. on p. 153 [poor]; Morris (1952) p. 181, pl. 5, fig. 9 [poor]; Kira (1955) pl. 19, fig. 14.

Characteristically about three-fourths inch long with brown and white spots over a bluish-gray dorsum, pitted orange-brown margins with violet extremities, and an orange-brown base.

Several specimens in the recent Micronesian collections were found under rocks and loose coral in shallow water on both windward and leeward ocean reef flats of Bikini and Eniwetok. Two other specimens were found living on the leeward side of Onotoa; one among coral on the seaward reef flat, the other in a cranny on a small reef in a pass through the leeward reef. In Hawaii, Ostergaard (1950) collected living specimens in shallow water on Waikiki reef.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Tuamotu and Marquesas islands, and from southern Japan and Hawaii south to New Guinea and the Loyalty Islands. Also reported from northeastern Australia. Common in Micronesia.

Cypraea (Erosaria) poraria Linné, 1758.
Tinker (1952) p. 152, 4 figs. on p. 153; Hirase and Taki (1951) pl. 94, fig. 10; Kira (1955) pl. 19, fig. 17.

Characteristically about 0.5 to 0.75 inch long with irregular white spots over a brownish dorsum, a violet base, and pitted violet margins and extremities.

Ordinarily collected among rocks below low tide line on seaward reef flats. One specimen in the present collections was found living among dead coral branches of a small reef on the sandy lagoon shelf at Ifaluk. The top of this reef was usually 2 to 3 feet below the water surface at mean low tide and was never exposed even during spring tides. Abbott (1950) reports *C. poraria* living under boulders on the seaward portion of the barrier reef at Cocos-Keeling Atoll. According to Ingram (1947) this species is extremely rare in Hawaii. Over a period of several years, he collected only one living specimen, taken from the branches of living coral at a depth of several feet on Waikiki reef, in a moderately heavy surf.

GEOGRAPHIC RANGE: USNM collections are from Ceylon and Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society Islands, and from southern Japan and Hawaii south to New South Wales, Australia, and New Caledonia. Reported from Mauritius. Common in Micronesia.

Subgenus MONETARIA Troschel, 1863

Cypraea (Monetaria) annulus Linné, 1758.
Morris (1952) p. 181, col. pl. 5, fig. 4 [as *C. annulata* Linné]; Kira (1955) pl. 19, fig. 20.

Characteristically 0.5 to 0.75 inch long. Grayish white with a dark orange ring encircling the central dorsum, which is commonly a darker bluish gray.

The collections studied include only four lots of this species on which there is ecological data. Most of the specimens were found a few feet below low tide line in beds of turtle grass on sandy lagoon shelves. A few were living intertidally in rocky pools on lagoon reef flats. According to Allan (1950), large numbers of *C. annulus* commonly occur together on the coral reefs of northeastern Australia, under stones in shallow water. She also reports their occurrence along the rocky shore of southeastern Australia, at and below low tide line.

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Red Sea eastward throughout the Indian and Pacific oceans to Samoa and Palmyra Atoll, and from southern Japan south to northeastern Australia and New Caledonia. Not found in Hawaii. Uncommon in Micronesia.

Cypraea (*Monetaria*) *moneta* Linné, 1758.
Tinker (1952) p. 156, 3 figs. on p. 157; Morris (1952) p. 181, col. pl. 5, fig. 1; Kira (1955) pl. 19, fig. 23.

Characteristically 0.75 to 1 inch long with thickened margins and extremities and a polished pale yellow or greenish-yellow dorsum.

Lives in a variety of habitats. Abundant under and among rocks and coral heads in shallow water on seaward and lagoon reef flats. Ordinarily occurs below low tide line but also found intertidally in moist rock crevices and in tide pools. Commonly found among seaweed in shallow bays and on sandy lagoon shelves and slopes in about 2 to 12 feet of water. Also taken on small lagoon reefs, on exposed lagoon sand flats, and along rocky ocean shores.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northeastern Australia and New Caledonia. *C. moneta* ranges into the eastern Pacific, occurring at Clipperton Island (Hertlein and Emerson, 1953), and at Cocos and the Galapagos Islands (Ingram, 1951), but it is not found on the west coast of the Americas. It is the most common small cowry in Micronesia.

Subgenus LURIA Jousseaume, 1884

Cypraea (*Luria*) *isabella* Linné, 1758.
Tinker (1952) p. 148, 3 figs. on p. 149; Morris (1952) p. 180, pl. 5, fig. 6 (poor); Kira (1955) pl. 19, fig. 26.

Characteristically about 1.25 to 1.5 inches long with an orange or fawn-colored dorsum, dark brown or orange extremities, and a white base. Dorsum covered with thin brown or blackish-brown longitudinal streaks.

Found under rocks and in crannies on seaward reef flats, on small lagoon reefs, and in shallow passes between reef segments. Occurs from just below low tide line to a depth of 8 to 10 feet. Apparently most abundant on leeward reefs or in protected lagoon waters, where it is not exposed to a heavy surf.

GEOGRAPHIC RANGE: Collections are from the African coast (Natal, Durban, South Africa, to the Red Sea) eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to New Guinea and New Caledonia. Reported from southeastern Australia. *C. isabella* also ranges into the eastern Pacific, occurring at Clipperton Island (Hertlein and Emerson, 1953) and at Cocos and the Galapagos Islands (Ingram, 1951), but it is not found on the west coast of the Americas. Common in Micronesia.

Subgenus TALPARIA Troschel, 1863

Cypraea (*Talparia*) *argus* Linné, 1758.
Hirase and Taki (1951) pl. 92, fig. 1; Kira (1955) pl. 20, fig. 13.

Characteristically 3 to 4 inches long with three medium brown transverse bands on a light fawn-colored dorsum over which are scattered numerous medium brown rings or eyes. Base whitish with four large dark brown splotches, two on each lip.

None of the few specimens in the recent Micronesian collections were taken alive, but data for recently dead specimens indicate that this species lives below low tide line near the edge of seaward reefs.

GEOGRAPHIC RANGE: USNM collections are from the south China coast and the East Indies eastward through the Pacific to Hawaii and Samoa, and from the Ryukyu and Mariana islands south to New Caledonia. Reported from the Seychelles, Madagascar, Mauritius, and northern Australia. Uncommon in Micronesia.

Cypraea (*Talparia*) *talpa* Linné, 1758.
Tinker (1952) p. 144, 3 figs. on p. 145; Kira (1955) pl. 20, fig. 11.

Characteristically 2 to 3 inches long with dark brown margins, extremities, and teeth; white interstices; and a light brown dorsum

bearing four darker medium brown transverse bands.

Lives among rocks on both seaward and lagoon reef flats, invariably below low tide line.

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Seychelles eastward through the Pacific Ocean to Hawaii and the Tuamotus, and from the Ryukyu and Mariana islands south to northern Australia and New Caledonia. Uncommon in Micronesia.

Subgenus CALLISTOCYPRAEA Schilder, 1927

Cypraea (*Callistocypraea*) *testudinaria* Linné, 1758.
Hirase and Taki (1951) pl. 92, fig. 7; Kira (1955) pl. 20, fig. 18.

Characteristically about 4.5 to 6 inches long. Elongate, with a light tan dorsum mottled and dotted with dark brown and covered with numerous fine white specks. Base fawn-colored.

Lives on seaward reef flats and on small lagoon reefs, invariably below low tide line.

GEOGRAPHIC RANGE: USNM records are from Zanzibar on the east African coast; from Mauritius, Ceylon and Cocos-Keeling Atoll in the Indian Ocean; and from the Ryukyu, Philippine, Caroline, Marshall, Gilbert, Samoan, and Fiji islands in the Pacific. Uncommon in Micronesia, and not reported from Australia or Hawaii.

Subgenus PALMADUSTA Iredale, 1930

Cypraea (*Palmadusta*) *fimbriata* Gmelin, 1791.
Tinker (1952) p. 154, 8 figs. on p. 155; Kira (1955) pl. 19, fig. 2.

Characteristically 0.5 to 0.625 inch long with a transverse band of irregular brown markings extending medially over a purplish gray dorsum and columellar margin onto a white base. Extremities brilliant purple both dorsally and ventrally. Teeth and interstices white.

Of the recent Micronesian specimens, only one was taken alive—from branching coral (*Stylophora* sp.) on the lagoon reef slope off Ine Village, Arno Atoll. Locality notes accompanying the Hawaiian specimens of *C. fimbriata* in the U. S. National Museum contain the following observation by the collector, Ditlev Thaanum: "Among branches of coral, live and dead, under rocks, etc. Most frequent on rocks covered with a bright orange-yellow sponge (?) the color of the animal of [*C.*] *fimbriata*."

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Gulf of Suez eastward through the Pacific to the Society, Tuamotu, and Hawaiian islands, and from southern Japan south to New Guinea. Reported from northern Australia and New South Wales. Rare in Micronesia.

Subgenus ERRONEA Troschel, 1863

Cypraea (*Erronea*) *caurica* Linné, 1758.
Hirase and Taki (1951) pl. 93, fig. 11.

Characteristically 1.5 to 2 inches long with numerous medium brown specks over a greenish or bluish dorsum, commonly with three brownish transverse dorsal bands, produced margins and extremities which are whitish with dark brown spots, a white base and teeth, and light orange interstices.

Only two specimens in the recent Micronesian collections were taken alive. Both were found under rocks on shallow lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to Fiji and Samoa, and from southern Japan south to northern Australia and New Caledonia. Uncommon in Micronesia. Not reported from Hawaii.

Subgenus STAPHYLAEA Jousseaume, 1884

Cypraea (*Staphylaea*) *nucleus* Linné, 1758.
Tinker (1952) p. 160, 2 figs. on p. 161; Morris (1952) p. 182, col. pl. 5, fig. 7; Kira (1955) pl. 18, fig. 20.

Characteristically 0.5 to 0.75 inch long with

pale rust-colored pustules and ridges covering a grayish dorsum, a distinct median dorsal furrow, extremities produced and beaked, and teeth extending over the base onto the margins.

Apparently lives below low tide line on both seaward and lagoon reef flats. The one specimen in the present Micronesian collections which was taken alive came from among small reefs on the sandy lagoon shelf at Ifaluk. These reefs are never exposed, their surfaces ordinarily being covered by 3 to 5 feet of water at low tide.

GEOGRAPHIC RANGE: USNM collections are from East Africa and Mauritius eastward throughout the Indian and Pacific oceans to the Society, Tuamotu, and Line islands, and from southern Japan south to New Guinea and New Caledonia. Reported from northern Australia and Hawaii. Uncommon in Micronesia.

Family CASSIDIDAE—Helmet Shells

Genus CASSIS Scopoli, 1777

Cassis cornuta (Linné, 1758).
Hirase and Taki (1951) pl. 97, fig. 1; Tinker (1952) p. 128, fig. on p. 129; Morris (1952) p. 183, pl. 38, fig. 14.

The largest species of *Cassis*, commonly 10 to 14 inches long. Whitish with 7 or 8 dark brown rays on the outer lip. Aperture flesh-colored and polished.

Ordinarily lives in sand among small reefs, on lagoon slopes at depths of 5 to 20 feet. According to USNM collection notes by John Wells, the Arno natives claim that *C. cornuta* comes up from the lagoon bottom onto the lagoon reef flat during new moon. Perhaps corroborating this behavior is the fact that two of the present Ifaluk specimens were collected during new moon along the shallow shore of the lagoon.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to Samoa, and from the Ryukyu and Marshall islands south to the Caroline Islands. Reported from southern Japan, Hawaii, and northeastern Australia. Fairly common in Micronesia.

Genus PHALIUM Link, 1807

Subgenus CASMARIA H. and A. Adams, 1853

Phalium (*Casmaria*) *vibex* (Linné, 1758).
Tinker (1952) p. 130, 3 figs. on p. 131; Morris (1952) p. 183, pl. 38, fig. 13.

Characteristically about two inches long, whitish or brownish with dark brown rays on the outer lip and a polished white aperture.

Apparently lives on seaward reef flats in shallow water below low tide line. The one specimen in the recent Micronesian collections which was taken alive was found among rocks in about 3 feet of water on the seaward reef flat at Ifaluk. Edmondson (1946) reports that, although *P. vibex* is a common Hawaiian species, it is seldom taken alive on the reefs. This comment indicates that the species lives in deeper water off the reef front.

GEOGRAPHIC RANGE: Fairly common throughout the Indo-Pacific. USNM collections are from East Africa and Mauritius eastward throughout the Indian and Pacific oceans to Hawaii and the Tuamotu Islands, and from the Ryukyu Islands south to northern Australia and New Caledonia.

Family CYMATIIDAE—Triton Shells

Genus CYMATIUM Röding, 1798

Subgenus LAMPUSIA Schumacher, 1817

Cymatium (*Lampusia*) *chlorostomum* (Lamarck, 1822).
Tinker (1952) p. 126, 2 figs. on p. 127; Morris (1952) p. 184, col. pl. 6, fig. 10.

Characteristically 1.75 to 4 inches long and solid, with strong varices, prominent columellar plications, and apertural teeth. Shell whitish with brownish spots and a bright orange aperture and columella.

Ordinarily lives among rocks and in tide pools on windward ocean reef flats, com-

monly a few feet below low tide line toward the reef edge. Occasionally found on lagoon reef flats. One specimen in the recent Micronesian collections was taken in 18 feet of water from the sandy lagoon slope of Rongelap Atoll. At Eniwetok, Morrison observed this species feeding on ceriths.

GEOGRAPHIC RANGE: USNM collections are distributed from Mauritius eastward through the Indian and Pacific oceans to the Society and Marquesas islands, and from southern Japan south to Cocos-Keeling Atoll, the Caroline and Fiji islands. Common in Micronesia. Reported from Hawaii but not from Australia. *C. chlorostomum* also occurs in southeast Florida, the West Indies, and Bermuda.

Cymatium (*Lampusia*) *gemmatum* (Reeve, 1844) (syn. *mundum* Gould, 1851).
Tinker (1952) p. 124, 2 figs. on p. 125.

Characteristically 1.25 to 1.75 inches long. Shell white or whitish with a yellowish hairy periostracum and a white aperture and columella.

Found under rocks and coral on shallow reef flats, ordinarily just below low tide line on lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections are from Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to Hawaii and the Tuamotu Islands, and from southern Japan south to the East Indies, the Solomon Islands, and Fiji. Reported from Mauritius and northern Australia. Uncommon in Micronesia.

Subgenus GUTTURNIUM Mörch, 1852

Cymatium (*Gutturnium*) *muricinum* Röding, 1798 (syn. *tuberosum* Lamarck, 1822).
Morris (1952) p. 184, col. pl. 6, fig. 1 [as *C. tuberosum* Lamarck]; Tinker (1952) p. 124, 2 figs. on p. 125 [as *C. tuberosum* Lamarck].

Characteristically 1.75 to 3 inches long, with a slender, elongate anterior canal and a conspicuous columellar callus. Teeth, lips, and columella polished white. Aperture dark orange-brown within.

Ordinarily lives in sandy lagoons, frequently a few feet below low tide line on lagoon shelves and lagoon reef flats, and to depths of 150 feet on lagoon floors. Also found on the deeper portions of seaward reef flats.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward throughout the Indian and Pacific oceans to the Hawaiian and Tuamotu islands, and from southern Japan south to New Guinea and New Caledonia. Fairly common in Micronesia, but not reported from Australia. *C. muricinum* also occurs in southeast Florida, the West Indies, and Bermuda.

Genus CHARONIA Gistel, 1848

Charonia tritonis (Linné, 1758).
Hirase and Taki (1951) pl. 95, fig. 9; Tinker (1952) p. 114, fig. on p. 115; Morris (1952) p. 185, col. pl. 6, fig. 9; Kira (1955) pl. 21, fig. 15.

The largest member of the family Cymatiidae and one of the largest gastropods in the Indo-Pacific, commonly reaching up to 16 to 18 inches long.

Apparently lives on sandy bottoms of shallow bays and lagoons, and in deeper water off the edge of seaward reefs.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to Hawaii and Samoa, and from the Ryukyu and Mariana islands south to the New Hebrides and Fiji. Also reported from northern Australia and New South Wales.

Family BURSIDAE—Frog Shells

Genus BURSA Röding, 1798

Bursa bubo (Linné, 1758) (syn. *rubeta gigantea* E. A. Smith, 1914).
Tinker (1952) p. 120, fig. on p. 121 [as *B. lampas* Linné].

A ponderous shell easily recognized by its large size, specimens commonly attaining a length of 9 to 10 inches.

Apparently lives among coral at a depth of several fathoms off the edge of seaward reefs.

GEOGRAPHIC RANGE: USNM records are from East Africa, the Ryukyu, Philippine, Caroline, Marshall, and Fiji islands, and from New Caledonia. Reported from northern Australia and Hawaii. Specimens from Micronesia are few, possibly because of their relatively inaccessible habitat.

Bursa bufonia (Gmelin, 1791).
Hirase and Taki (1951) pl. 96, fig. 8; Tinker (1952) p. 120, 4 figs. on p. 121; Morris (1952) p. 186, col. pl. 6, fig. 4.

Characteristically 2 to 2.5 inches long with curved anterior and posterior canals. Shell whitish with brown markings. Commonly encrusted with calcareous algae, vermetids, and Foraminifera. Aperture white or yellowish within.

Ordinarily lives among rocks and loose coral on windward ocean reef flats, commonly in turbulent water just shoreward of the reef edge, and invariably below low tide line. In the Marshall Islands, *B. bufonia* was abundant along the windward shores of Bikini, Eniwetok, Rongelap, and Rongerik, on the seaward reef flats which are covered by 6 inches to a foot of water at extreme low tide. The species was also found on windward lagoon reef flats of atolls with broad lagoons, where a strong surf is present on the windward lagoon shore (e.g., Bikini and Eniwetok). At Ifaluk, specimens were taken only on the windward ocean reef flats. Also, at Onotoa and Saipan *B. bufonia* was found exclusively along windward ocean shores.

GEOGRAPHIC RANGE: USNM records are from New Guinea, the Philippine, Mariana, Marshall, Gilbert, Caroline, Solomon, Samoan, Tuamotu, Phoenix, and Line islands. Reported from Mauritius in the Indian Ocean, from southern Japan, and from Hawaii, but not from Australia. A very common species in Micronesia.

Bursa granularis Röding, 1798 (syn. *affinis* Broderip, 1833; *granifera* Lamarck, 1816).
Tinker (1952) p. 122, 2 figs. on p. 123 [as *B. affinis* Broderip]; Morris (1952) p. 185, col. pl. 6, fig. 5 [as *B. affinis* Broderip].

Characteristically 0.75 to 2 inches long. Recognized by its laterally compressed shell and its vertically aligned varices.

Lives under rocks and in tide pools of seaward reef flats, both windward and leeward, ordinarily slightly below low tide line.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward throughout the Indian and Pacific oceans to Hawaii and the Tuamotu Islands, and from southern Japan south to New Caledonia, but the species is uncommon in Micronesia. There are worn USNM specimens from Clipperton and Clarion islands in the eastern Pacific; the Clipperton occurrence is confirmed by Hertlein and Emerson (1953). *B. granularis* is reported from northern Australia. It also occurs in southeast Florida and the West Indies, but it is not found on the west America coast.

Family TONNIDAE—Tun Shells

Genus TONNA Brünnich, 1772
(syn. *Cadus* Röding, 1798; *Dolium* Lamarck, 1801; *Cadium* Link, 1807)

Tonna cepa (Röding, 1798) (syn. *olearium* of authors).

Characteristically 3 to 4.5 inches long. Differs from *T. perdix* in having a more globose shell, deep, almost channelled sutures, and somewhat shouldered whorls. Also, the spiral grooves of *T. cepa* are deeper than those of *T. perdix*.

Probably lives in offshore ocean waters. The recent Micronesian collections include only one shell, obtained from natives at Onotoa. Abbott (1950) reports that empty shells of this species are plentiful in reef pools at Cocos-Keeling Atoll.

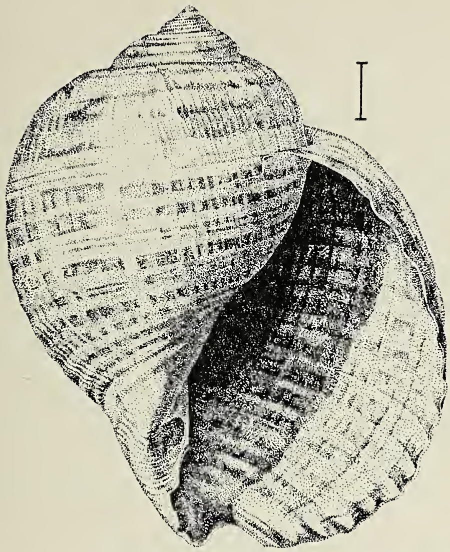


FIG. 17. *Tonna cepa* (Röding). Onotoa Atoll, Gilbert Islands (USNM 607555).

GEOGRAPHIC RANGE: USNM collections are from East Africa and Mauritius eastward to Fiji, and from the Ryukyu Islands south to New Guinea. Uncommon in Micronesia. Not reported from Hawaii.

Tonna perdix (Linné, 1758).
Hirase and Taki (1951) pl. 98, fig. 7; Tinker (1952) p. 132, figs. on p. 133; Morris (1952) p. 183, pl. 38, fig. 11.

Characteristically 4.5 to 7 inches long and elongate with a raised spire. See *T. cepa* for comparative description.

T. perdix lives in offshore ocean waters, but empty shells are frequently washed ashore. According to Tinker (1949), this species occurs in less than 10 to well over 100 feet of water but is most abundant in depths greater than 75 feet. Allan (1950) reports *T. perdix* to be a common shell on the outer reefs of northern Australia.

GEOGRAPHIC RANGE: USNM collections are from East Africa eastward through the Indian and Pacific oceans to Hawaii and Samoa. Reported from southern Japan and the Great Barrier Reef, Australia. A fairly common species in the Indo-Pacific.

Genus MALEA Valenciennes, 1833

Malea pomum (Linné, 1758).
Hirase and Taki (1951) pl. 98, fig. 3 [as *Quimalea pomum* (Linné)]; Tinker (1952) p. 136, 3 figs. on p. 137; Morris (1952) p. 183, pl. 38, fig. 12.

Characteristically 2 to 3 inches long with well-defined teeth on its thickened outer lip.

The recent Micronesian collections contain many empty shells taken from seaward reefs and beaches, indicating that *M. pomum* lives in deeper water beyond the reef edge. According to Tinker (1949), this species is the third most abundant member of the Tonnidae in Hawaii. He reports that it is most numerous at depths of about 100 feet, is occasionally taken in shallower water, and is uncommon at depths of less than 40 or 50 feet.

GEOGRAPHIC RANGE: Common in Micronesia, though rarely found alive. USNM collections are from East Africa eastward through the Indian and Pacific oceans to Samoa, and from the Ryukyu and Hawaiian islands south to the Celebes and New Caledonia. Reported from northern Australia.

Family MURICIDAE—Murex and Rock Shells

Genus MUREX Linné, 1758

Subgenus CHICOREUS Montfort, 1810

Murex (*Chicoreus*) *brunneus* (Link, 1807) (syn. *adustus* Lamarck, 1822).
Hirase and Taki (1951) pl. 109, fig. 4 [as *Chicoreus rubicundus* (Perry)].

Characteristically 1.5 to 2 inches long.

Ordinarily found in quiet, protected water from about 1 foot below low tide line to depths of 150 to 200 feet. Specimens studied were collected from crannies in both dead and living coral on small lagoon reefs, and also from among coral-algal rock on sandy lagoon floors.

GEOGRAPHIC RANGE: USNM records are from Mauritius and the coast of India east-

ward through the Indian and Pacific oceans to the Marshall, Gilbert, and Samoan islands, and from southern Japan, the Ryukyu and Mariana islands south to New Guinea and New Caledonia. Reported from northern Australia, but not found in Hawaii. Fairly common in Micronesia.

Genus Drupa Röding, 1798

Drupa grossularia Röding, 1798 (syn. *digitata* Lamarck, 1816).
Tinker (1952) p. 96, 3 figs. on p. 97 [as *D. digitata* Lamarck]; Morris (1952) p. 187, pl. 39, fig. 3, col. pl. 8, fig. 5 [as *Sistrum digitatum* Lamarck]; Kira (1955) pl. 23, fig. 3.

Characteristically 1 to 1.5 inches long, with an orange aperture and, in adult specimens, with fingerlike protuberances on the outer lip. This *Drupa* is commonly so encrusted with coralline algae, vermetids, Foraminifera, and other growth, that its shape is entirely obscured and it appears to be part of its substrate.

Ordinarily found on windward ocean reef flats, clinging to the rocks near low tide line. Less frequently occurs on leeward ocean reefs. Only one specimen in the recent Micronesian collections was from a lagoon habitat. It was taken alive from coral-algal rock at a depth of 32 to 38 feet in the lagoon entrance west of Saipan.

GEOGRAPHIC RANGE: Apparently limited to the Pacific, and fairly common in Micronesia. USNM collections are from Formosa and the Philippines eastward to the Hawaiian, Society, and Tuamotu islands, and from the Ryukyus south to New Guinea and Fiji. Reported from northern Australia. In the Indian Ocean, *D. grossularia* is replaced by the subspecies *D. lobata* which is recognized by its dark brown aperture.

Drupa morum Röding, 1798 (syn. *horrida* Lamarck, 1816; *violacea* Schumacher, 1817; *neritoides* Gmelin, 1791, not Linné, 1758).
Hirase and Taki (1951) pl. 110, fig. 8; Tinker (1952) p. 94, 3 figs. on p. 95 [as *D. horrida* Lamarck]; Kira (1955) pl. 23, fig. 8.

Characteristically about one and three-fourths inches long.

D. morum lives among rocks and in crannies of windward ocean reef flats. It is also common on windward lagoon reef flats of broad atolls, such as Bikini and Eniwetok, where the surf is strong, but it seldom occurs on leeward reefs. Ordinarily, it is found near low tide line, or on the reef edge, but it has also been taken from tide pools across the entire reef flat. Specimens are commonly so overgrown with coralline algae, vermetids, Foraminifera, and *Hipponix* they are almost indistinguishable from the reef surface.

GEOGRAPHIC RANGE: USNM collections are from Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to the East Indies and New Caledonia. Common in Micronesia. Reported from northern Australia and also from Clipperton Island in the eastern Pacific (Hertlein and Emerson, 1953).

Drupa ricinus (Linné, 1758) (syn. *hystrix* Linné, 1758, not Lamarck, 1822; *arachnoides* Lamarck, 1816).
Hirase and Taki (1951) pl. 110, fig. 11; Tinker (1952) p. 96, 3 figs. on p. 97.

Characteristically 0.75 to 1 inch long, and ordinarily encrusted with coralline algae, vermetids and other growths.

Habitat similar to *D. morum*.

GEOGRAPHIC RANGE: USNM collections are from Mauritius eastward through the Indian and Pacific oceans to the Marquesas Islands, and from southern Japan and Hawaii south to the Great Barrier Reef, Australia, and New Caledonia. Very common in Micronesia. Hertlein and Emerson (1953) report *D. ricinus* from Clipperton Island in the eastern Pacific.

Drupa rubusidaeus Röding, 1798 (syn. *hystrix* Lamarck, 1822).
Hirase and Taki (1951) pl. 110, fig. 10.

Characteristically 1 to 1.25 inches long.

Lives on both windward and leeward ocean reef flats, under rocks and loose coral and in tide pools near, or a few feet below, low tide line. Also taken on living coral heads (*Pocillopora* sp.) off the seaward reef edge in 10 to 15 feet of water.

GEOGRAPHIC RANGE: USNM collections are from East Africa and Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from the Ryukyu Islands south to New Guinea and New Zealand. Reported from northeastern Australia but not from Hawaii. Uncommon in Micronesia.

Genus MORULA Schumacher, 1817

Morula anaxeres (Kiener, 1836).

FIG. 18. *Morula anaxeres* (Kiener). Ifaluk Atoll, Caroline Islands (USNM 614192).

Characteristically about one-half inch long with prominent white tubercules and a polished, dark brown aperture.

Ordinarily lives under rocks and in rocky tide pools of windward ocean reef flats. Also found on leeward ocean reefs and on windward lagoon reefs. Occurs from the upper intertidal zone to just shoreward of the reef edge.

GEOGRAPHIC RANGE: USNM collections are from the west coast of India, and the Philippine, Caroline, and Marshall islands. There is one USNM record from Palmyra Atoll but none from Hawaii. Reported from the Ryukyu Islands. Uncommon in Micronesia. Probably more widespread and possibly recorded as *M. uva* because of its similarity to that common species.

Morula concatenata (Lamarck, 1822) (syn. *fragum* Blainville, 1832).
Hirase and Taki (1951) pl. 110, fig. 18.

Characteristically about one inch long and yellowish-white with a purple-violet or orange-red aperture.

The recent Micronesian collections contain but one specimen, found living on small lagoon reefs in about one foot of water at Eniwetok. According to earlier USNM collection notes, *M. concatenata* occurs exclusively on living coral.

GEOGRAPHIC RANGE: USNM records are from Mauritius eastward through the Indian and Pacific oceans to the Hawaiian and Society islands, and from the Ryukyu Islands south to New Guinea and Fiji. Uncommon in Micronesia.

Morula elata (Blainville, 1832) (syn. *spectrum* Reeve, 1846; *ochrostoma* Tryon, 1880, not Blainville, 1832).

Characteristically 0.75 to 1 inch long and white both exteriorly and within the aperture.

Lives on small lagoon reefs, on coral in channels between reef segments and on sea-

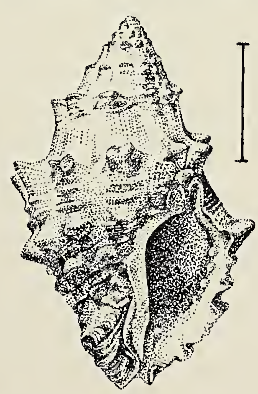


FIG. 19. *Morula elata* (Blainville). Kwajalein Atoll, Marshall Islands (USNM 486005).

ward reef flats, both windward and leeward, from about low tide line to depths of 25 feet. According to Bayer, *M. elata* occurs exclusively on branches of living coral, most frequently on *Porites* sp., but also on *Stylophora* sp. and *Seriatopora* sp.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM collections are from Java and Borneo east to the Tuamotu Islands, and from southern Japan and Hawaii south to Queensland, Australia, and Fiji. Fairly common in Micronesia.

Morula fiscella (Gmelin, 1791).
Tinker (1952) p. 92, 3 figs. on p. 93.

Characteristically about 0.75 to 1 inch long with brown bands and a pale violet aperture.

The recent Micronesian collections contain only two lots of this species, one found under rocks in a tide pool on the seaward reef flat at Ifaluk and the other found among intertidal rocks of Tomil Harbor beach, Yap.

GEOGRAPHIC RANGE: USNM records are from South Africa, Mauritius, Java, Borneo, Gulf of Siam, China coast, southern Japan, the Philippines, northern Australia, and Fiji. Reported from Hawaii. Uncommon in Micronesia.

Morula granulata (Duclos, 1832) (syn. *tuberculata* Blainville, 1832).
Hirase and Taki (1951) pl. 110, fig. 15; Tinker (1952) p. 90, 2 figs. on p. 91 [as *M. tuberculata* Blainville]; Morris (1952) p. 187, pl. 39, fig. 11 [as *M. tubercula* Blainville].

Characteristically about one inch long.
Habitat similar to that of *Drupa morum*.

GEOGRAPHIC RANGE: USNM records are from the entire coast of Africa eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to the East Indies, New Guinea, and New Caledonia. Common in Micronesia, but not reported from Australia.

Morula ochrostoma (Blainville, 1832).
Tinker (1952) p. 90, 5 figs. on p. 91 (poor).

Characteristically 1 to 1.5 inches long. Entirely white except for its orange aperture which distinguishes it from *M. elata*.

Lives among rocks and corals on seaward and lagoon reef flats, both windward and leeward, from near low tide line to a depth of 6 feet or so.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from the Philippines eastward to the Hawaiian and Society islands, and from southern Japan south to Queensland, Australia, and the Loyalty Islands. Uncommon in Micronesia.

Morula triangulatum (Pease, 1867).

FIG. 20. *Morula triangulatum* (Pease). Eniwetok Atoll, Marshall Islands (USNM 581860).

Characteristically 0.75 to 1 inch long with a purple aperture, and triangular in shape.

Lives among rocks and in tide pools of both windward and leeward ocean reef flats from the lower to the upper intertidal zone.

GEOGRAPHIC RANGE: USNM records are from the Red Sea, Mauritius, the East Indies, the Philippine, Marshall, Hawaiian, Line, Tuamotu, Samoan, Tonga, and Fiji islands and from the Schouten Islands off New Guinea. Fairly common in Micronesia.

Morula uva Röding, 1798 (syn. *nodus* Lamarck, 1816; *morus* Lamarck, 1822).
Morris (1952) p. 187, col. pl. 8, fig. 1; pl. 39, fig. 2 [as *M. nodus* St. Vincent].

Characteristically 0.5 to 0.75 inch long.

Found in crannies or among rocks on exposed reef flats, both seaward and lagoon.

Has also been taken, though uncommonly, from small reefs on lagoon floors.

GEOGRAPHIC RANGE: USNM records are from South Africa and Mauritius eastward through the Indian and Pacific oceans to the Tuamotu and Society islands and to Clipperton Island in the eastern Pacific, and also from the Ryukyu and Hawaiian islands south to the East Indies and Fiji. Reported from northern Australia. Common in Micronesia.

Genus MACULOTRITON Dall, 1904

Maculotriton digitalis (Reeve, 1844).

FIG. 21. *Maculotriton digitalis* (Reeve). Ifaluk Atoll, Gilbert Islands (USNM 614193).

Characteristically about one-half inch long. Sculptured with spiral cords and low, broad transverse ribs. Whitish in color with a spiral pattern of yellowish or chestnut-brown spots, which is frequently obscured.

Ordinarily found under rocks and in tide pools on windward ocean reef flats.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from southern Japan, the Bonin, Caroline, Marshall, Gilbert, Hawaiian, Line, Society, and Tuamotu islands. Reported from northeastern Australia. Uncommon in Micronesia.

Genus THAIS Röding, 1798

Thais armigera (Link, 1807).

Hirase and Taki (1951) pl. 110, fig. 2; Tinker (1952) p. 98, 4 figs. on p. 99 [as *T. affinis* Reeve].

Characteristically about three inches long and whitish with a yellowish-pink aperture.

Ordinarily found clinging to rocks of windward ocean reef flats, just shoreward of the reef edge. Also occurs along windward lagoon margins of broad atolls where the lagoon reef flat exhibits features of a seaward reef. Invariably found in shallow water, either just below low tide line or in reef flat tide pools. Commonly so thickly encrusted with coralline algae, Foraminifera, vermetids, and *Hipponix* it is difficult to distinguish from the reef surface.

GEOGRAPHIC RANGE: USNM records are from Mauritius and Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands, and from southern Japan south to the Solomon Islands and New Caledonia. Reported from northern Australia and Hawaii. Fairly common in Micronesia.

Thais hippocastanum (Linné, 1758) (syn. *aculeata* Deshayes, 1844; *pseudohippocastanum* Dautzenberg, 1929).

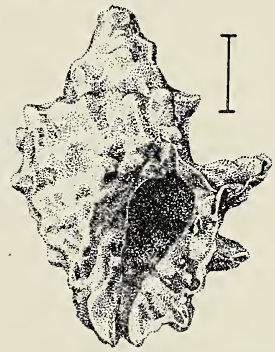


FIG. 22. *Thais hippocastanum* (Linné). Kwajalein Atoll, Marshall Islands (USNM 607586).

Characteristically 1.5 to 2.5 inches long. Resembles *T. tuberosa* in its shape, knobby surface, and yellowish-white aperture. However, unlike *T. tuberosa*, the brown color on its outer lip extends into the aperture as spiral bands, and the brown color on its columella is diffused instead of in distinct spots.

Ordinarily lives among rocks and in sandy-rocky tide pools on seaward reef flats, both windward and leeward. Occurs across the reef from near low tide line to the upper intertidal zone. Also found, though infrequently, on lagoon reef flats. Specimens are often heavily encrusted and appear to be part of the reef surface.

GEOGRAPHIC RANGE: USNM records are from the east coast of Africa eastward through

the Indian and Pacific oceans to Palmyra Atoll and the Tuamotu Islands, and from southern Japan south to New Guinea, Fiji, and Tonga. Fairly common in Micronesia, but not reported from Australia or Hawaii.

Thais tuberosa Röding, 1798 (syn. *pica* Blainville, 1832).

Characteristically 1.5 to 2.25 inches long. Triangular in shape and covered with broad, pointed knobs. Aperture typically yellowish-white with a few large, dark brown spots on both the outer lip and columella.

The recent Micronesian collections include only two specimens, both from the windward shore of Saipan. They were found living in shallow water on rocky intertidal reef flats.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from the Philippines eastward through Micronesia to the Society and Tuamotu islands, and from southern Japan and the Ryukyu Islands south to northern Australia. Apparently uncommon in Micronesia. Not reported from Hawaii.

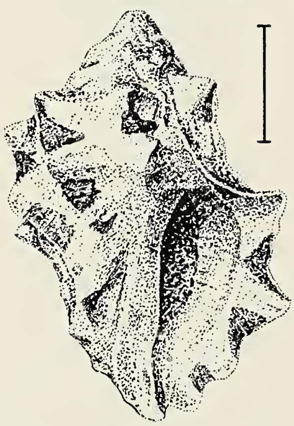


FIG. 23. *Thais tuberosa* Röding. Samoa (USNM 305758).

Genus PURPURA Bruguière, 1789

Purpura persicum (Linné, 1758).

Characteristically 2 to 3.5 inches long. Exterior brownish with spiral lines of alternating brown and white elongate spots. Aperture orange or flesh-colored.

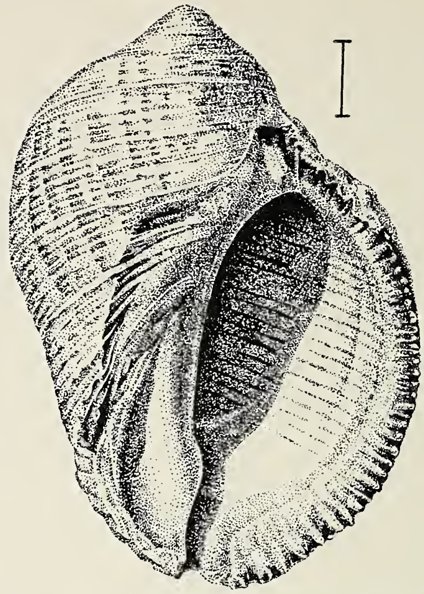


FIG. 24. *Purpura persicum* (Linné). Ifaluk Atoll, Caroline Islands (USNM 614202).

A single specimen was found living on the windward shore of Ifaluk, clinging to the rocky edge of the seaward reef flat, exposed to the breaking surf.

GEOGRAPHIC RANGE: USNM records are from Mauritius, Ceylon, Cocos-Keeling Atoll, the East Indies, and the Philippine, Ryukyu, Bonin, Mariana, Caroline, Gilbert, and Loyalty islands. Reported from northern Australia but not from Japan or Hawaii. Uncommon in Micronesia.

Genus NASSA Röding, 1798

Nassa sertum (Bruguière, 1789).

Hirase and Taki (1951) pl. 110, fig. 7 [as *Nassa francolinus* Bruguière]; Tinker (1952) p. 88, 5 figs. on p. 89; Morris (1952) p. 191, pl. 39, fig. 12.

Characteristically 1.5 to 2 inches long.

Ordinarily ives among rocks near or slightly below low tide line on both seaward and lagoon reef flats, commonly just shoreward of the reef edge. One specimen, from Ifaluk, was found on a small lagoon reef in 3 to 5 feet of water.

GEOGRAPHIC RANGE: USNM records are from Anna Island and Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands, and from the Ryukyu, Hawaiian and Line islands south to New Guinea and New Caledonia. Fairly common in Micronesia. The foregoing range includes *N. francolinus*, the Hawaiian form or subspecies which is entirely smooth and bears well-defined tentlike markings.

Family MAGILIDAE—Coral Snails

Genus CORALLIOPHILA H. and A. Adams, 1853

Coralliophila bulbiformis (Conrad, 1837).
Tinker (1952) p. 104, 2 figs. on p. 105.

Characteristically 0.75 to 1.25 inches long. Shell white or yellowish, and purple within the aperture. Some authors regard *C. bulbiformis* as a subspecies of *C. violacea*. However, it is here considered a distinct species, because its shell is covered with scaly spiral ridges, whereas the shell of *C. violacea* is relatively smooth.

A single specimen was found living on a small lagoon reef in about 10 feet of water on the sandy lagoon shelf at Ifaluk.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from southern Japan, the Ryukyu, Philippine, Caroline, Hawaiian and Tuamotu islands and from Samoa, New Guinea, and northern Australia. Uncommon in Micronesia.

Coralliophila erosa (Röding, 1798) (syn. *exarata* Pease, 1861; *galea* Reeve, 1846).
Tinker (1952) p. 104, 3 figs. on p. 105 [as *C. deformis* Lamarck].

Characteristically 1.25 to 1.75 inches long. Shell white both exteriorly and within the aperture and sculptured with fine, scaly spiral ridges and obscure axial ribs which are particularly prominent on the spire.

The recent Micronesian collections contain only one specimen, taken from coral at a depth of about six feet in the lagoon at Ifaluk.

GEOGRAPHIC RANGE: USNM records are from Mauritius and Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to Hawaii and Samoa, and from southern Japan south to the East Indies, New Guinea, and Fiji. Not reported from Australia. Uncommon in Micronesia.

Coralliophila violacea (Kiener, 1836) (syn. *neritoidea* Gmelin, 1791; *squamulosa* Reeve, 1846).
Hirase and Taki (1951) pl. 111, fig. 8; Tinker (1952) p. 104, 3 figs. on p. 105 [as *C. neretoidea* Lamarck].

Characteristically 1 to 1.5 inches long and whitish with a bright violet aperture.

C. violacea is a solitary species which lives in pocketlike depressions on coral. It invariably occurs on living corals and may be dependent upon them for nourishment. Specimens in the recent Micronesian collections were found on species of *Porites* on small lagoon reefs and on small reef patches in lagoons. *C. violacea* lives below low tide line, typically at depths of a few feet.

The eggs of this species are held in capsules under the shell of the female until the pelagic larvae hatch. After a free-swimming period, the larvae settle upon coral, and, as noted above, this habitat is maintained by the adult form.

GEOGRAPHIC RANGE: The commonest *Coralliophila* in the Indo-Pacific. USNM records are from Mauritius in the Indian Ocean eastward through the Pacific to the Hawaiian and Tuamotu islands, and from southern Japan south to northern Australia and the Loyalty Islands.

Genus QUOYULA Iredale, 1912

The collections studied include two species of *Quoyula; Q. monodonta* with very fine, spiral ridges, and *Q. madreporarum* with coarser, scaly spiral ridges. *Q. madreporarum* tends to be more elongate than *Q. monodonta*. However, both species vary in shape, because they

live embedded in coral, and their shells become adapted to the configuration of the narrow cavities in which they reside. Thus the only consistent means of recognition is the difference in external sculpture. The sculpturing is, however, commonly obscured by encrustations, and consequently it is difficult to distinguish one species from the other.

Quoyula madreporarum (Sowerby, 1834).
Tinker (1952) p. 104, 3 figs. on p. 105 [as *Rhizochilus madreporarum* Sowerby].

Micronesian specimens are characteristically 0.5 to 0.75 inch long, but Hawaiian specimens attain lengths of 1.25 inches. Shell whitish with a purple aperture.

Q. madreporarum lives embedded in pocketlike depressions on coral. It is ordinarily found a few feet below low tide line on small lagoon reefs or on seaward reef flats. It apparently lives exclusively on living coral and commonly on branching species. Specimens in the present collections were found on species of *Stylophora*, *Pocillopora* and *Montipora*. Encrustations on the shells of both *Q. madreporarum* and *Q. monodonta* make them difficult to distinguish from their coral substrate.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from southern Japan, the Caroline, Marshall, and Hawaiian islands, and from Johnston Island and Pearl and Hermes Reef. Uncommon in Micronesia.

Quoyula monodonta (Blainville, 1832).
Hirase and Taki (1951) pl. 111, fig. 14.

Characteristically about one-half inch long and whitish with a purple aperture. Perfect specimens possess a single tooth at the base of the columella.

Q. monodonta lives in pocketlike depressions on coral. The recent Micronesian collections indicate that it occurs exclusively on living coral, typically on branching species such as *Pocillopora*, *Seriatopora*, and *Stylophora*, and on branching forms of *Porites*. It is most commonly found on small reefs in lagoons or protected harbors, from slightly below low tide line to depths of 30 or 40 feet, but it has also been taken on seaward reef flats, just shoreward of the reef edge. At Ifaluk, specimens were found with egg cases enveloped under the foot.

GEOGRAPHIC RANGE: USNM records are from the Red Sea and Ceylon in the Indian Ocean eastward through the Pacific beyond the Hawaiian and Tuamotu islands to the coast of Lower California at Cape San Lucas, Acapulco, and Espiritu Santo Island; and also from the Philippine and Mariana islands south to Queensland, Australia, and the Loyalty Islands. Reported from southern Japan. Very common in Micronesia.

Genus MAGILUS Montfort, 1810

Magilus antiquus Montfort, 1810.

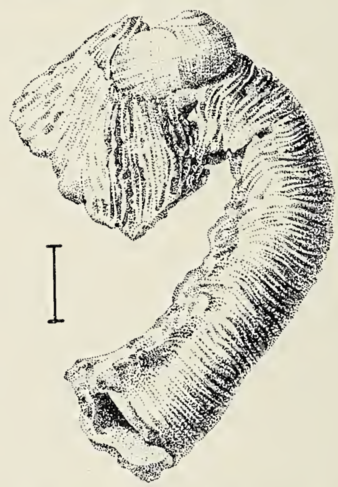


FIG. 25. *Magilus antiquus* Montfort. Composite drawing of two specimens from Saipan, Mariana Islands (USNM 595414).

M. antiquus is a mollusk of curious behavior and specific habitat. It begins life as a freeliving gastropod with a symmetrically shaped shell but soon settles upon living coral, becomes embedded, and develops an extraordinary shell. As the coral grows, *M. antiquus* secretes a tubelike extension of its aperture. It stops up its original shell with calcareous material, then vacates it, and lives in the free end of the tube, which extends to and opens upon the surface of the coral. It is not known

whether *M. antiquus* obtains nourishment directly from the coral or whether it receives its food from the surrounding water through the open tube.

Both the primary shell and its tubular extension are calcareous and chalky white. The primary shell is typically about 1 inch long; the tube may be as long as 6 inches.

The recent Micronesian collections contain only two specimens, taken alive in 5 to 10 feet of water from the lagoon off Mañagaha Island, Saipan. They were obtained from a solid head of living *Goniastraea retiformis* (Lamarck) by breaking open the coral.

GEOGRAPHIC RANGE: USNM records are from Mauritius, Ceylon, Cocos-Keeling Atoll, Java, southern Japan, and Saipan only. Reported from northern Australia and from Hawaii. *M. antiquus* is probably more abundant than the above records indicate but has rarely been collected because of its inconspicuous mode of life.

Genus MAGILOPSIS Sowerby, 1919

Magilopsis lamarcki (Deshayes, 1863).
Hirase and Taki (1951) pl. 111, fig. 18 [as *Leptoconchus lamarkii* Deshayes]; Tinker (1952) p. 104, 3 figs. on p. 105 [as *Leptoconchus lamarkii* Deshayes].

Uncommon in collections, probably because it lives embedded in coral and, consequently, has been overlooked. The shell of *M. lamarcki* is thin, elongate, characteristically chalky white, and about an inch long. Unlike *Magilus antiquus*, it does not secrete a tube.

Among the specimens studied, one was collected by Morrison at Eniwetok, slightly below low tide line on the leeward lagoon reef flat. He reports that *M. lamarcki* occurs in burrows in living coral, oriented apex down. The burrows have only a small opening at the coral surface, like the holes of boring clams of the genus *Lithophaga*. At Raroia Atoll, in the Tuamotus, Morrison found the commensal clam *Barclayia incerta* (Deshayes) living in the same burrow with *M. lamarcki.* They were embedded at the base of coral (*Acropora* spp.) on the leeward ocean reef flat. Specimens from Saipan were embedded, apex down, in slightly irregular burrows in living *Goniastrea retiformis* Lamarck. A single dead specimen was found at Onotoa on living coral in 5 to 20 feet of water in a pass through the leeward reef. USNM specimens from Hawaii, collected by Ditlev Thaanum, were taken from a depth of 150 to 300 feet off Waikiki. They also were embedded in coral. Thaanum observed that the shells were unattached but the burrows were so narrow the mollusks could not turn within them.

The eggs of *M. lamarcki* are laid in capsules and remain within the parental burrow until they hatch into pelagic larvae, which eventually settle on coral and form their own chambers.

GEOGRAPHIC RANGE: Collection records for *M. lamarcki* are few, but they indicate a widespread occurrence in the Indo-Pacific. USNM specimens are from Mauritius in the Indian Ocean and from the Mariana, Marshall, Gilbert, Hawaiian, and Tuamotu islands in the Pacific. The species is reported also from southern Japan and Formosa.

Family COLUMBELLIDAE—Dove Shells

Genus COLUMBELLA Lamarck, 1799

Columbella turturina Lamarck, 1822.
Kira (1955) pl. 28, fig. 6.

Characteristically about one-half inch long with a yellow or whitish exterior, a white aperture, and pink outer and inner lips.

Lives on small lagoon reefs at depths of 10 to 30 feet. Two specimens in the recent Micronesian collections were found living on colonies of *Seriatopora* sp.

GEOGRAPHIC RANGE: USNM records are from Ceylon and Cocos-Keeling Atoll eastward to Hawaii and Samoa, and from southern Japan south to northern Australia and the Loyalty Islands. Uncommon in Micronesia.

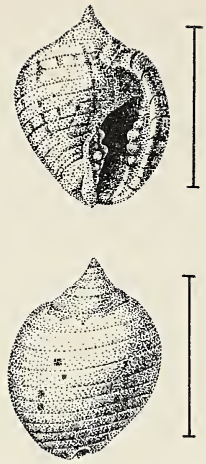


FIG. 26. *Columbella turturina* Lamarck. Onotoa Atoll, Gilbert Islands (USNM 607538).

Family BUCCINIDAE—Buccinid Snails

Genus CANTHARUS Röding, 1798

Subgenus POLLIA Sowerby, 1834

Cantharus (*Pollia*) *fumosus* (Dillwyn, 1817).

Characteristically 0.75 to 1.5 inches long. Closely resembles *C. undosus* with its raised brown spiral cords, white aperture with orange lips, and hairy periostracum. However, *C. fumosus* is more elongate and, unlike *C. undosus*, possesses axial ribs.

The recent Micronesian collections include only one lot of four specimens taken among intertidal rocks of Tomil Harbor beach, Yap Island.

FIG. 27. *Cantharus* (*Pollia*) *fumosus* (Dillwyn). Cebu, Philippines (USNM 419449).

GEOGRAPHIC RANGE: Apparently more widespread than *C. undosus*, particularly in the Indian Ocean where *C. undosus* is reported only from Cocos-Keeling Atoll. USNM records are from Mauritius, the Red Sea, and the coast of India, eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan south to New Guinea and Fiji. Uncommon in Micronesia. Not reported from Hawaii.

Cantharus (*Pollia*) *undosus* (Linné, 1758).

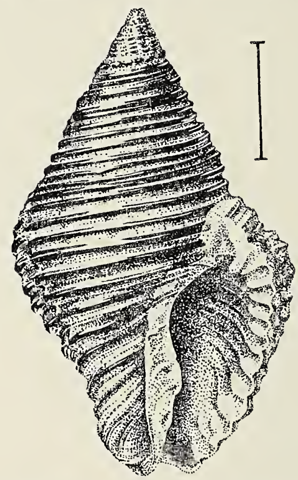


FIG. 28. *Cantharus* (*Pollia*) *undosus* (Linné). Luzon, Philippines (USNM 303327).

Characteristically about one and one-half inches long with numerous, dark brown, evenly spaced, raised spiral cords on all whorls and typically covered with a hairy periostracum. Aperture white with dark orange lips. Resembles *C. fumosus* but may be distinguished from that species by its broader shell and its complete lack of axial ribs.

C. undosus ordinarily lives in rock crevices on seaward reef flats, near or a few feet below low tide line. It also occurs in reef flat tide pools above low tide line and on small lagoon reefs at depths of a few feet.

GEOGRAPHIC RANGE: USNM collections are from Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands, and from the Marianas south to New Guinea and the

Loyalty Islands. Reported from southern Japan and the Great Barrier Reef, Australia, but not from Hawaii. Fairly common in Micronesia.

Genus ENGINA Gray, 1839

Engina mendicaria (Linné, 1758).
Hirase and Taki (1951) pl. 105, fig. 8.

Characteristically one-half inch long and blackish brown with spiral yellowish-white bands and a brown aperture.

Ordinarily lives under rocks near or just below low tide line on seaward reef flats, both windward and leeward. Also found in rocky tide pools across the entire reef flat.

GEOGRAPHIC RANGE: USNM records for this common Indo-Pacific species are from the Red Sea and Mauritius eastward through the Indian and Pacific oceans to Samoa, and from southern Japan and Hawaii south to the Loyalty and Tonga islands.

Genus COLUBRARIA Schumacher, 1817

Colubraria strepta Cossmann, 1903.
Hirase and Taki (1951) pl. 105, fig. 2; Tinker (1952) p. 80, 2 figs. on p. 81.

Characteristically 1.5 to 2 inches long.

The only specimen in the recent Micronesian collections was taken off Ine Village, Arno Atoll, on rocks on a small lagoon reef in about 6 feet of water.

GEOGRAPHIC RANGE: Apparently limited to the Pacific and uncommon in Micronesia. USNM records are from New Guinea, the Marshall, Line, Hawaiian, and Tuamotu islands, and from Fiji and Samoa.

Genus CADUCIFER Dall, 1904

Caducifer decapitatus (Reeve, 1844).

Characteristically about three-fourths inch long. Columnar in shape and white with thin brown axial ribs interrupted by a few white spiral lines. Invariably found with its apex broken.

FIG. 29. *Caducifer decapitatus* (Reeve). Oshima Osumi, Japan (USNM 273493).

At Onotoa and Saipan *C. decapitatus* was collected from crannies in both living and dead coral on small lagoon reefs and in shallow passes between seaward reefs. At Arno Atoll, it was found on branching coral (*Pocillopora* sp.) off the seaward reef edge. It ordinarily lives below low tide line, commonly at depths of 4 to 10 feet.

GEOGRAPHIC RANGE: USNM records are from Mauritius, southern Japan, and the Mariana, Gilbert, Fiji, Samoan and Hawaiian islands. Uncommon in Micronesia.

Family NASSARIIDAE—Mud Snails

Genus NASSARIUS Dumeril, 1806

Nassarius crenelliferus (A. Adams, 1851).

Characteristically 0.75 to slightly less than 1 inch long and grayish with two indistinct dark brown spiral color bands on the body whorl. Outer lip and parietal callus polished white.

The recent Micronesian collections contain only one specimen which was found living

FIG. 30. *Nassarius crenelliferus* (A. Adams). Yap Island, western Carolines (USNM 614204).

among intertidal rocks on the beach at Tomil Harbor, Yap.

GEOGRAPHIC RANGE: USNM records of this uncommon Micronesian species are from southern Japan, the Gulf of Siam, and the Caroline Islands. Not reported from Australia or Hawaii.

Nassarius jonasi (Dunker, 1846).

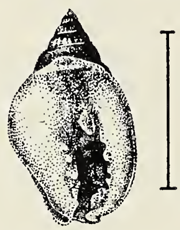


FIG. 31. *Nassarius jonasi* (Dunker.) Yap Island. western Carolines (USNM 614205),

Characteristically 0.5 to 0.75 inch long with a conspicuous parietal callus and prominent axial ribs on the body whorl. Shell medium brown. Callus, lips, and teeth polished white.

According to Allan (1950), *N. jonasi* lives in estuaries and lagoons and is ordinarily found in shallow water among seaweed. The recent Micronesian collections only contain one specimen, an individual found living among intertidal rocks on the beach at Tomil Harbor, Yap.

GEOGRAPHIC RANGE: The above-mentioned specimen from the Caroline Islands is the only USNM record. Reported from northern Australia and New South Wales, but not from Hawaii. Uncommon in Micronesia.

Nassarius papillosus (Linné, 1758).
Tinker (1952) p. 82, 2 figs. on p. 83; Morris (1952) p. 190, pl. 39, fig. 16.

Characteristically about 1.5 to 2 inches long and light brown or fawn-colored with conspicuous white nodules.

Ordinarily lives on sandy lagoon floors and in sand pockets on small lagoon reefs, ranging from low tide line to depths of 10 or 20 feet. One specimen was collected at Onotoa from a sand pocket below low tide line on the leeward ocean reef. Apparently *N. papillosus* is a carnivorous scavenger which feeds upon other mollusks and upon decaying organic matter. It is frequently collected from lobster traps to which it is presumably attracted by the bait.

GEOGRAPHIC RANGE: USNM records of this fairly common Micronesian species are from Mauritius, Cocos-Keeling Atoll, Hong Kong, southern Japan, and from the Philippine, Caroline, Gilbert, Line, and Hawaiian islands. Reported from northern Australia.

Family FASCIOLARIIDAE—Spindle Shells

Genus FASCIOLARIA Lamarck, 1799

Fasciolaria filamentosa (Röding, 1798).
Hirase and Taki (1951) pl. 99, fig. 12.

Characteristically 4 to 6 inches long and yellowish or flesh-colored with many dark brown spiral grooves.

Lives among coral below low tide line off the outer edge of seaward reefs.

GEOGRAPHIC RANGE: USNM records are from Tanganyika, East Africa, Mauritius and Cocos-Keeling Atoll in the Indian Ocean, and from the Ryukyu, Palau, Caroline and Marshall islands in the Pacific. Reported from Australia but not from Hawaii. Fairly common in Micronesia.

Genus LATIRUS Montfort, 1810

Latirus barclayi (Reeve, 1847).

Adult specimens characteristically measure 2 to 4 inches long. Shell whitish with a straw-colored periostracum and commonly dark brown between the broad axial nodes. Aperture white within.

Lives on sandy lagoon bottoms and among rocks on seaward reef flats, from near low tide line to depths of 20 feet.

GEOGRAPHIC RANGE: USNM records are from Mauritius, Cocos-Keeling Atoll, the Philippine, Mariana, and Marshall islands, and from Samoa and Fiji. Uncommon in Micronesia. Not reported from Hawaii.

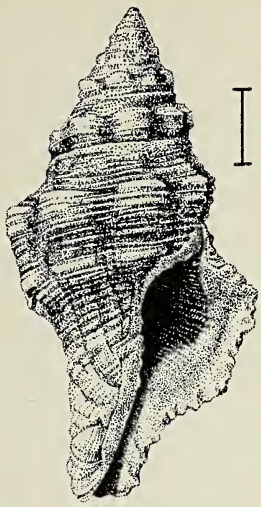


FIG. 32. *Latirus barclayi* (Reeve). Guam, Mariana Islands (USNM 487445).

Genus PERISTERNIA Mörch, 1852

Peristernia chlorostoma (Wood, 1828).
Tinker (1952) p. 76, 3 figs. on p. 77.

Characteristically 0.75 to 1 inch long with a canary yellow aperture.

P. chlorostoma lives on seaward and lagoon reef flats, both windward and leeward, among rocks and loose coral, in tide pools, and on the sandy-rocky reef surface. It is most commonly found near low tide line on seaward reef flats, just shoreward of the reef edge.

GEOGRAPHIC RANGE: Apparently limited to the Pacific. USNM records are from the Marshall, Phoenix, Samoan, and Tuamotu islands only. Reported from Hawaii. There are many USNM specimens from the Marshall Islands, but none from elsewhere in Micronesia.

Peristernia nassatula (Lamarck, 1822).
Hirase and Taki (1951) pl. 100, fig. 5.

Characteristically 1.25 to 1.5 inches long with a violet aperture.

P. nassatula ordinarily lives in rock crevices on seaward reef flats. However, one specimen in the recent Micronesian collections was taken by Cloud at night on the intertidal lagoon sand flats of Uliga Island, Majuro Atoll.

GEOGRAPHIC RANGE: USNM collections are from Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society and Tuamotu islands, and from southern Japan, the Philippine and Mariana islands south to the Loyalty Islands and Fiji. Fairly common in Micronesia. There are USNM specimens from the Line Islands, but none from Hawaii. Reported from the Great Barrier Reef, Australia.

Family MITRIDAE—Miter Shells

Genus MITRA Lamarck, 1799

Mitra (Mitra) mitra (Linné, 1758) (syn. *episcopalis* Linné, 1758).
Hirase and Taki (1951) pl. 100, fig. 13; Tinker (1952) p. 52, figs. on p. 53 [as *M. episcopalis* Linné].

The largest *Mitra* in the Indo-Pacific, commonly attaining a length of 6 inches. Shell smooth and white with conspicuous orange spots.

M. mitra typically lives on sandy lagoon shores in shallow water but is also found in sand pockets on shallow seaward reef flats. It ordinarily remains buried during the day and is active at night.

GEOGRAPHIC RANGE: USNM collections are from East Africa throughout the Indian and Pacific oceans to the Society and Tuamotu islands, and from the Ryukyu and Hawaiian islands south to the Great Barrier Reef, Australia, and New Caledonia. Common in Micronesia. Reported from southern Japan.

Mitra (Mitra) stictica (Link, 1807) (syn. *pontificalis* Lamarck, 1811; *thiara* Wood, 1825).
Hirase and Taki (1951) pl. 100, fig. 12; Tinker (1952) p. 54, 3 figs. on p. 55.

Characteristically 2.5 to 3 inches long, white with squarish orange-colored blocks, and nodulose below the sutures.

Ordinarily lives in sand pockets on seaward reef flats, slightly below low tide line. Also found at depths of 5 to 15 feet in grooves

and surge channels just seaward of the reef edge. Like *M. mitra*, *M. stictica* remains buried during the day but comes out at night.

GEOGRAPHIC RANGE: USNM collections are from East Africa throughout the Indian and Pacific oceans to the Society and Tuamotu islands, and from the Ryukyu and Hawaiian islands south to New Guinea and New Caledonia. Reported from northern Australia. Apparently more common than *M. mitra* in Micronesia.

Subgenus SWAINSONIA H. and A. Adams, 1853

Mitra (*Swainsonia*) *casta* (Gmelin, 1791).

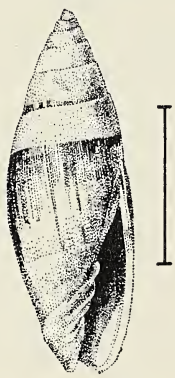


FIG. 33. *Mitra* (*Swainsonia*) *casta* Gmelin. Ifaluk Atoll, Caroline Islands (USNM 614201).

Characteristically 1 to 2 inches long, smooth and white with dark brown bands above each suture, the brown coloring ordinarily being worn away, particularly on the body whorl.

One specimen in the recent Micronesian collections was found living in sand between small reefs on the sandy lagoon slope at Ifaluk in about 10 feet of water. A dead specimen was dredged from the bottom of Bikini lagoon in 18 to 30 feet of water.

GEOGRAPHIC RANGE: USNM records are from the Philippine, Caroline, Marshall, Fiji, Samoan, Tuamotu, and Marquesas islands. Reported from southern Japan and from the Loyalty Islands (Bouge and Dautzenberg, 1922), but not from Hawaii. Uncommon in Micronesia.

Genus STRIGATELLA Swainson, 1840

Strigatella litterata (Lamarck, 1811) (syn. *bizonalis* Lamarck, 1822).
Hirase and Taki (1951) pl. 101, fig. 9; Morris (1952) p. 195, pl. 39, fig. 17 (poor).

Characteristically 1 to 1.5 inches long with yellowish-white hieroglyphic markings.

Ordinarily lives below low tide line among rocks on seaward reef flats. Also found in tide pools and moist rock crevices across the entire reef flat. Records in recent Micronesian collections indicate that *S. litterata* is most plentiful on windward ocean reefs or windward lagoon reefs of broad atolls, although it has also been taken on leeward reefs.

GEOGRAPHIC RANGE: According to USNM records and published reports, *S. litterata* is distributed from East Africa (Natal, Durban, South Africa to the Red Sea) eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to the East Indies, New Caledonia, and the Loyalty Islands. Not reported from Australia. Very common in Micronesia.

Strigatella lutea (Quoy and Gaimard, 1833) (syn. *acuminata* Swainson, 1824, not Gmelin, 1791).
Tinker (1952) p. 64, fig. on p. 65 [as *M. acuminata* Swainson].

Characteristically about one inch long and dull yellow in color.

Lives in rocky tide pools on seaward and lagoon reef flats, windward and leeward.

GEOGRAPHIC RANGE: USNM collections are from Mauritius eastward through the Pacific to the Society and Tuamotu islands, and from southern Japan and Hawaii south to New Guinea and the Solomons. Reported from New Caledonia but not from Australia. Uncommon in Micronesia.

Strigatella paupercula (Linné, 1758).
Hirase and Taki (1951) pl. 101, fig. 11 [as *Mitra zebra* Lamarck].

Characteristically 1 to 1.5 inches long with a variable color pattern of yellowish-white longitudinal stripes on a dark blackish-brown background.

Lives among rocks and in tide pools of seaward reef flats, ranging from the extreme seaward edge of the flat to the upper intertidal zone. Most frequently taken on windward reefs but also found on leeward reefs. Abbott (1950) reports this species from shallow, lagoon waters at Cocos-Keeling Atoll.

GEOGRAPHIC RANGE: USNM collections are from East Africa and the Red Sea through the Indian and Pacific oceans to Samoa, and from southern Japan and Palmyra south to the East Indies and New Caledonia. Reported from Hawaii and northern Australia. Fairly common in Micronesia.

Genus VEXILLUM Röding, 1798

Vexillum (*Vexillum*) *gruneri* (Reeve, 1844).

Characteristically about one inch long and white with narrow brown spiral bands.

Frequently found intertidally along sandy lagoon shores. The recent Micronesian collections include two specimens taken at night —one from the intertidal lagoon shore of

FIG. 34. *Vexillum* (*Vexillum*) *gruneri* (Reeve). Ifaluk Atoll, Caroline Islands (USNM 614200).

Uliga Island, Majuro Atoll, and another from a lagoon sandspit at Ifaluk. One specimen was dredged from 72 feet of water off the seaward shore of Bikini Island.

GEOGRAPHIC RANGE: USNM records are from southern Japan, the Philippine, Caroline, and Marshall islands, Samoa, and New Caledonia. Reported from northern Australia but not from Hawaii. Uncommon in Micronesia.

Vexillum (*Vexillum*) *plicaria* (Linné, 1758).

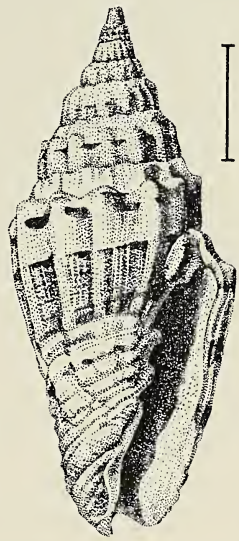


FIG. 35. *Vexillum* (*Vexillum*) *plicaria* Linné. Andaman Islands (USNM 305600).

Characteristically about one and one-half inches long and white with dark brown bands and a dark brown apex.

The recent Micronesian collections contain only one worn specimen, dredged from four feet of water off Yaptown, Yap. Specimens from the Philippines in the U. S. National Museum collections were dredged from a depth of 60 feet.

GEOGRAPHIC RANGE: USNM collections are from the Andaman Islands and the East Indies to New Guinea, Fiji, and southern Japan. Reported from northern Australia but not from Hawaii. Uncommon in Micronesia.

Subgenus COSTELLARIA Swainson, 1840

Vexillum (*Costellaria*) *exasperata* (Gmelin, 1791).
Tinker (1952) p. 56, 3 figs. on p. 57.

Characteristically 0.5 to 0.75 inch long. Grayish or whitish with strong axial ribs shouldered below the suture and crossed by many fine spiral grooves. The axial ribs are commonly whitish at the shoulders and occasionally brown in the middle of the whorl. Aperture white with four columellar plications.

Lives in sandy lagoons from low tide line to depths of 150 feet.

GEOGRAPHIC RANGE: According to USNM collections and published reports, distributed from South Africa and the Red Sea eastward through the Indian and Pacific oceans to the Marquesas Islands, and from the Ryukyu and Hawaiian islands south to the East Indies, New Caledonia, and the Loyalty Islands. Not reported from Australia. Uncommon in Micronesia.

Genus PUSIA Swainson, 1840

Pusia nodosa (Swainson, 1840).
Tinker (1952) p. 62, 2 figs. on p. 63.

Characteristically about one-half inch long and white with a yellow aperture.

Lives among rocks and in tide pools across seaward reef flats, ranging from just shoreward of the reef edge to the upper intertidal zone. Specimens in the recent Micronesian collections were taken from both windward and leeward ocean reefs but not from lagoon reefs.

GEOGRAPHIC RANGE: USNM collections are from Mauritius eastward through the Pacific to the Society and Tuamotu islands, and from southern Japan and Hawaii south to the Caroline Islands and New Caledonia. Not reported from East Africa or Australia. Fairly common in Micronesia.

Genus SCABRICOLA Swainson, 1840

Subgenus CHRYSAME H. and A. Adams, 1853

Scabricola (*Chrysame*) *cucumerina* (Lamarck, 1811) (syn. *ferrugata* Wood, 1825).
Tinker (1952) p. 62, 3 figs. on p. 63.

Characteristically 0.5 to 1 inch long and orange-red with white blotches.

Ordinarily lives among rocks and in tide pools of windward ocean reef flats, at or near low tide line. Not reported from lagoon reefs.

GEOGRAPHIC RANGE: USNM collections of this common Micronesian species are from Mauritius eastward through the Pacific to the Hawaiian and Tuamotu islands, and from the Ryukyu Islands south to New Guinea and New Caledonia. Reported from northern Australia.

Scabricola (*Chrysame*) *pertusa* (Linné, 1758).

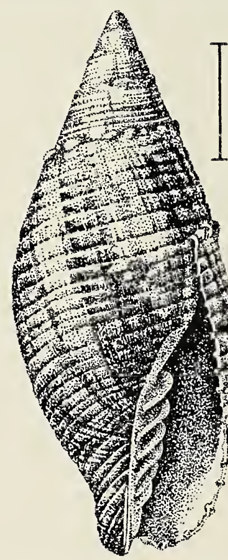


FIG. 36. *Scabricola* (*Chrysame*) *pertusa* (Linné). Ifaluk Atoll, Caroline Islands (USNM 614203).

Characteristically about 1.5 to 2 inches long and brownish or yellowish with conspicuous incised spiral lines and nodulose sutures.

There is a single specimen from Ifaluk in the recent Micronesian collections. It was found living in a sand pocket on the windward ocean reef flat, below low tide line in water about one foot deep.

GEOGRAPHIC RANGE: USNM records of this uncommon Micronesian species are from the East Indies, Philippines, Marquesas, Samoa, Mariana, and Caroline islands. Not reported from Hawaii.

Family VASIDAE—Vase Shells

Genus VASUM Röding, 1798

Vasum ceramicum (Linné, 1758).
Hirase and Taki (1951) pl. 99, fig. 8.

Much larger and higher spired than the commoner *V. turbinellus*. Typically 3 to 5 inches long.

The recent Micronesian collections include only two specimens, both of which were taken alive from rocks below low tide line on the windward lagoon reef flats at Ifaluk.

GEOGRAPHIC RANGE: Apparently limited to the Pacific and uncommon in Micronesia. USNM records are from the Philippine, Mariana, Caroline, Marshall and Gilbert islands, New Guinea, New Caledonia, Fiji, Samoa and Niaufou. Reported from the Ryukyu Islands and northern Australia but not from Hawaii.

Vasum turbinellus (Linné, 1758) (syn. *nigra* Perry, 1811; *cornigera* Lamarck, 1822).
Hirase and Taki (1951) pl. 99, fig. 9.

A heavy, low-spired shell, characteristically 2.5 to 3 inches long.

According to records with the recent Micronesian collections, *V. turbinellus* lives in a variety of habitats. It is apparently most abundant on seaward reef flats, both windward and leeward, where it lives among rocks and in crannies in both living and dead coral. The species is commonly found in turbulent water just shoreward of the reef edge, but it also occurs in tide pools across the entire reef flat, ranging into the upper intertidal zone. In addition, it has been taken from surge channels of seaward reefs, on windward lagoon reef flats, on shallow small lagoon reefs, along exposed rocky beaches, and among seaweed on sandy lagoon shelves. It is frequently so heavily encrusted with coralline algae, Foraminifera, vermetids, and *Hipponyx* as to be difficult to distinguish from the reef surface.

GEOGRAPHIC RANGE: USNM collections are from the Red Sea and Mauritius eastward through the Indian and Pacific oceans to Samoa, and from the south China coast, the Ryukyu and Mariana islands south to New Caledonia. Reported from northern Australia but not from Hawaii. Very common in Micronesia.

Family CONIDAE—Cone Shells

Genus CONUS Linné, 1758

Conus adamsoni Broderip, 1836 (syn. *rhododendron* Couthouy, 1839).
Platt (1949) col. pl. on p. 73, fig. 5 [as *C. rhododendron*].

A very rare species. In the entire USNM collections there are only two specimens, one taken at Samoa by the U. S. Exploring Expedition, the other given by natives to collectors at Onotoa. There is no specific locality or ecologic data for either specimen. The species is reported from Australia (Platt, 1949), but not from Hawaii.

Conus arenatus Hwass, 1792.

Characteristically 1 to 2.25 inches long, coronate, and white with many fine, brown, spirally arranged spots that occasionally form a zig-zag or banded pattern.

The recent Micronesian collections contain only two worn specimens from Tomil Harbor, Yap; one from four feet of water in the harbor, the other from among dead coral heads on the tidal flat.

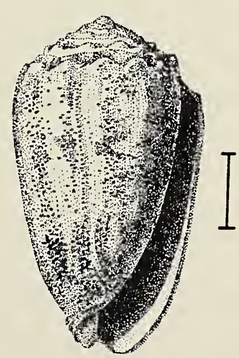


FIG. 37. *Conus arenatus* Hwass. Cebu, Philippines (USNM 303520).

GEOGRAPHIC RANGE: USNM collections are from all along the east African coast, eastward through the Indian and Pacific oceans to the Cook Islands, and from southern Japan south to northern Australia; but the species is uncommon in Micronesia. Not found in Hawaii.

Conus aulicus Linné, 1758 (syn. *episcopus* Hwass, 1789).
Platt (1949) p. 53, col. fig. 17; Kira (1955) pl. 37, fig. 14.

Characteristically 1.75 to 6 inches long and reddish-brown with white tent-shaped markings. Although some workers consider *C. episcopus* Hwass to be a distinct species, it is here considered synonymous with *C. aulicus.*

Lives among rocks on seaward reef flats, ordinarily along windward shores. Like many cones, *C. aulicus* has a venomous bite. An account of poisonous cone species, of wounds received, and of the biting mechanism is given by Clench and Kondo (1946). Like most cones, *C. aulicus* is nocturnal.

GEOGRAPHIC RANGE: USNM records are from Cocos-Keeling Atoll eastward through the Pacific to the Tuamotu Islands, and from the Ryukyu Islands south to northern Australia and New Caledonia, but the species is uncommon in Micronesia. Not found in Hawaii.

Conus capitaneus Linné, 1758.
Hirase and Taki (1951) pl. 114, fig. 3.

Characteristically 1.25 to 2.5 inches long.

The recent Micronesian collections include only three worn specimens. One was dredged from Tomil Harbor, Yap. Another was found among beach drift at Burok Island, Rongelap. The third, for which there is no specific locality data, is from Ifaluk.

GEOGRAPHIC RANGE: According to USNM records and published reports, this uncommon Micronesian species is found all along the African coast, eastward through the Indian and Pacific oceans to Tonga and Samoa; and from southern Japan, the Mariana, and Marshall islands south to eastern Australia. Not reported from Hawaii.

Conus catus Hwass, 1789.
Tinker (1952) p. 34, 2 figs. on p. 35; Kira (1955) pl. 36, fig. 16.

Characteristically 1.5 to 2.5 inches long and dark brown with irregular white spots.

Ordinarily lives under rocks and loose coral on windward ocean reef flats. Not reported from lagoon reefs.

GEOGRAPHIC RANGE: According to USNM records and published reports, this common Indo-Pacific cone occurs from Africa and the Red Sea eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus chaldeus (Röding, 1798) (syn. *vermiculatus* Lamarck, 1822).
Tinker (1952) p. 44, 2 figs. on p. 45 [as *C. vermiculatus*]; Kira (1955) pl. 36, fig. 11.

Characteristically 0.75 to 1.25 inches long. Body whorl white with dark brown, elongate vertical markings. Resembles, and is commonly found with, *C. ebraeus*, but may be distinguished from that species by the elongate markings on its shell which are unlike the squarish color blocks of *C. ebraeus.*

Ordinarily lives among rocks on seaward reef flats, both windward and leeward, but also reported from exposed, windward lagoon reef flats. Characteristically found below low tide line, generally in the extreme seaward zones of the reef, but also occurs in tide pools across the reef flat.

GEOGRAPHIC RANGE: USNM records of this common Indo-Pacific species are from East Africa and Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to the East Indies, New Guinea, and Fiji. Reported from northern Australia.

FIG. 38. *Conus coronalis* (Röding). Ifaluk Atoll, Caroline Islands (USNM 614199).

Conus coronalis (Röding, 1798) (syn. *piperatus* Reeve, 1844).

Characteristically 0.66 to 1.25 inches long. Body whorl bluish-gray with irregular brown flammules, spiral grooves, and granules. Spire coronate. Resembles *C. miliaris* but may be distinguished from that species by the dark brown coloration within its aperture and the dark brown flammules on its body whorl.

Ordinarily lives among rocks on windward ocean reef flats, generally at or near low tide line just shoreward of the reef edge. Not reported from lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections of this common Micronesian species are from the entire east African coast eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from the Ryukyu and Line islands south to the East Indies, New Guinea, and New Caledonia. Not re-reported from Australia or from southern Japan. Not found in Hawaii.

Conus distans Hwass, 1792.
Tinker (1952) p. 32, 2 figs. on p. 33; Kira (1955) pl. 37, fig. 4.

Characteristically 2.25 to 4 inches long and covered with a heavy yellowish periostracum. Resembles *C. virgo* but may be distinguished from that species by its coronate spire.

Ordinarily lives among rocks on seaward reef flats near or below low tide line. Apparently most abundant on the outer portion of windward ocean reef flats but also taken on the seaward reef edge, in tide pools across the entire seaward reef flat, and in shallow water on lagoon reef flats.

GEOGRAPHIC RANGE: USNM records are from the Philippines eastward through the Pacific to the Hawaiian and Society islands; and from the Ryukyu Islands south to New Guinea and the New Hebrides. Although fairly common in Micronesia, it is not reported from Australia or southern Japan.

Conus ebraeus Linné, 1758.
Hirase and Taki (1951) pl. 113, fig. 12; Tinker (1952) p. 34, 2 figs. on p. 35; Morris (1952) p. 202, col. pl. 7, fig. 4 [as *C. hebraeus*]; Kira (1955) pl. 36, fig. 9.

Characteristically 0.75 to 1.75 inches long, although Hawaiian specimens reach a length of 2 inches. White with squarish black color blocks.

Ordinarily lives among rocks or in holes and grooves on seaward reef flats, both windward and leeward. Typically occurs in fairly shallow water all across the reef flat and just seaward of the reef edge. Occasionally found on lagoon reef flats and on small reefs on lagoon floors.

GEOGRAPHIC RANGE: USNM collections of this very common Indo-Pacific cone are from the entire east African coast (including the Red Sea), eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia. According to Greene (1953), a live specimen was taken by Ted Dranga off the coast of Guanacosta Province, Costa Rica, Hertlein and Emerson (1953) report *C. ebraeus* from Clipperton Island in the eastern Pacific.

Conus eburneus Hwass, 1789.
Hirase and Taki (1951) pl. 113, fig. 15; Kira (1955) pl. 36, fig. 2.

Characteristically 1 to 2.75 inches long.

The recent Micronesian collections include worn specimens from Eniwetok, Rongelap, Saipan, and Yap, but only one specimen taken alive. It was collected at night by

Cloud on the intertidal lagoon shore of Uliga Island, Majuro Atoll.

GEOGRAPHIC RANGE: According to USNM records and published reports, distributed from Madagascar and Mauritius, eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan, the Mariana and Marshall islands, south to northern Australia and New Caledonia. Uncommon in Micronesia and not reported from Hawaii.

Conus flavidus Lamarck, 1810.
Tinker (1952) p. 38, 2 figs. on p. 39; Morris (1952) p. 204, col. pl. 7, fig. 6.

Characteristically 1 to 2.5 inches long. Resembles *C. lividus* with its purple aperture and medial white apertural band, but may be distinguished from that species by its smooth, noncoronate spire.

Ordinarily lives on seaward reef flats, among rocks near or slightly below low tide, line, or in intertidal pools. Also taken in surge channels through the edge of seaward reefs and on lagoon reef flats. Apparently most abundant along windward shores.

GEOGRAPHIC RANGE: USNM collections and published reports indicate this common Indo-Pacific species to be distributed from the east African coast (including the Red Sea and Persian Gulf) eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia. One of the most common cones in Hawaii.

Conus imperialis Linné, 1758.
Hirase and Taki (1951) pl. 113, fig. 9; Tinker (1952) p. 32, 2 figs. on p. 33; Morris (1952) p. 199, col. pl. 7, fig. 5; Kira (1955) pl. 36, fig. 8.

Characteristically 2 to 3.75 inches long.

Ordinarily found among rocks near low tide line on windward ocean reef flats. Also taken from surge channels through the edge of seaward reefs. Not reported from lagoon shores.

GEOGRAPHIC RANGE: According to USNM collections and published reports, distributed from Mauritius eastward through the Indian and Pacific oceans to the Tuamotu and Marquesas islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia. Uncommon in Micronesia.

Conus leopardus (Röding, 1798) (syn. *millepunctatus* Lamarck, 1822).
Tinker (1952) p. 30, 3 figs. on p. 31 [as *C. litteratus*].

Characteristically 2.5 to 6.5 inches long. See *C. litteratus* for further description.

Three live specimens were taken at Bikini Atoll, two on the lagoon reef flat, below low tide line, and one on the sandy lagoon floor at a depth of 10 feet.

GEOGRAPHIC RANGE: Because this species has been confused with *C. litteratus*, the range here is based only on specimens in the USNM collections. They indicate that *C. leopardus* is distributed from Mauritius in the Indian Ocean eastward through the Pacific to the Society and Marquesas islands, and from the Ryukyu and Hawaiian islands south to the Celebes and New Caledonia. It is apparently uncommon in Micronesia.

Conus litteratus Linné, 1758.
Hirase and Taki (1951) pl. 113, fig. 16.

Characteristically 2.5 to 5 inches long. *C. litteratus* and *C. leopardus* are commonly confused. Both are white with dark brown spots, but they differ in the appearance of the basal portion of their apertures. The tip of *C. leopardus* is truncated and white within, whereas that of *C. litteratus* is pointed and dark purple-brown within.

The recent Micronesian collections include only one group of individuals found living among small reefs in 3 to 4 feet of water on the sandy lagoon shelf at Ifaluk. These reefs are never out of water, even at low tide.

GEOGRAPHIC RANGE: USNM collections and published records indicate distribution from the east African coast (including the

Red Sea) eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan, the Mariana, and Marshall islands south to northern Australia and New Caledonia. Uncommon in Micronesia and not reported from Hawaii.

Conus lividus Hwass, 1792.
Tinker (1952) p. 38, 2 figs. on p. 39; Morris (1952) p. 203, col. pl. 7, fig. 13; Hirase and Taki (1951) pl. 114, fig. 9.

Characteristically 1 to 2.5 inches long. Closely resembles *C. flavidus* with its purple aperture and the medial white band within its aperture, but may be distinguished from that species by its coronate, tuberculated spire.

Ordinarily lives under rocks on seaward reef flats. Invariably occurs below low tide line in water from a few inches to a few feet deep.

GEOGRAPHIC RANGE: USNM collections and published reports indicate that this common Indo-Pacific species occurs all along the east African coast (including the Red Sea and Persian Gulf), eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia. It is especially common in Hawaii.

Conus magus Linné, 1758.
Hirase and Taki (1951) pl. 114, fig. 8.

Characteristically 1.25 to 3.25 inches long. The recent Micronesian material includes only five specimens. They were collected alive at night by Cloud from the intertidal zone of the sandy lagoon shore at Uliga Island, Majuro Atoll.

GEOGRAPHIC RANGE: According to USNM collections and published reports, distributed from Zanzibar on the east African coast, eastward through the Indian and Pacific oceans to the Tuamotu Islands; and from southern Japan and the Marshall Islands south to northern Australia and New Caledonia. Not reported from Hawaii. Uncommon in Micronesia.

Conus marmoreus Linné, 1758.
Hirase and Taki (1951) pl. 113, fig. 10; Tinker (1952) p. 30, 2 figs. on p. 31; Kira (1955) pl. 36, fig. 6.

Characteristically 1.75 to 4.5 inches long. Ordinarily lives among rocks below low tide line on seaward reef flats, both windward and leeward. Also common on lagoon reef flats and at depths of 5 to 15 feet on sandy lagoon shelves or slopes, among turtle grass or small reefs and in a few feet of water on lagoon reef flats. Nocturnal, venomous.

GEOGRAPHIC RANGE: USNM collections and published records indicate this common Micronesian species to be distributed from Madagascar and Mauritius eastward throughout the Indian and Pacific oceans to the Tuamotu Islands, and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus miles Linné, 1758.
Hirase and Taki (1951) pl. 114, fig. 5; Tinker (1952) p. 34, 2 figs. on p. 35; Morris (1952) p. 202, col. pl. 7, fig. 11; Kira (1955) pl. 36, fig. 23.

Characteristically 1.25 to 3.5 inches long.

Ordinarily found among rocks below low tide line on seaward reef flats, commonly just shoreward of the reef edge. Also taken on small lagoon reefs, in channels between seaward reef segments, and on lagoon reef flats. Apparently most abundant along windward shores.

GEOGRAPHIC RANGE: USNM collections and published records indicate this common Indo-Pacific species to be distributed from the east African coast (including the Red Sea), eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus miliaris Hwass, 1792.

Characteristically 0.75 to 1.25 inches long. Body whorl pinkish with two white, interrupted bands, numerous spiral grooves and granules, and a yellowish epidermis. Spire coronate. Resembles *C. coronalis* but may be distinguished from that species by the light pink color within its aperture and the absence of dark brown flammules on its body whorl.[3]

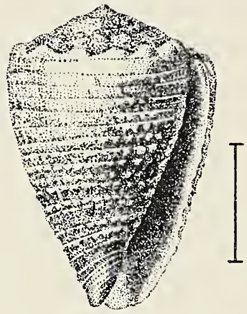


FIG. 39. *Conus miliaris* Hwass. Abamama Atoll, Gilbert Islands (USNM 433980).

Ordinarily lives among rocks on seaward reef flats, both windward and leeward, typically at or near low tide line or in tide pools. Also found on lagoon reef flats and among small reefs on sandy lagoon shelves.

GEOGRAPHIC RANGE: USNM collections and published records indicate this fairly abundant Micronesian species to be distributed from all along the east African coast (including the Red Sea), eastward through the Indian and Pacific oceans to the Society and Tuamotu islands, and from southern Japan and Palmyra south to the East Indies and New Caledonia. Not reported from Australia. There is a single USNM specimen from Hawaii, but the occurrence of *C. similaris* in Hawaii needs confirmation by additional collecting.

Conus mustelinus Hwass, 1792.

Characteristically 1 to 2.25 inches long.

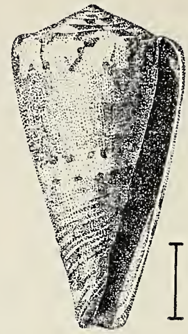


FIG. 40. *Conus mustelinus* Hwass. Cebu, Philippines (USNM 614195).

Body whorl straw-colored with a set of 2 or 3 spiral rows of dark brown spots on a white band around the middle and a second white band at the shoulder irregularly marked with brown flammules or spots. Spire smooth with many broad brown flammules.

The recent Micronesian collections include only two worn specimens from Yap; one dredged from four feet of water at Yaptown, the other taken from dead coral heads in Tomil Harbor. Probably lives below low tide line.

GEOGRAPHIC RANGE: USNM collections and published records indicate this uncommon species to be distributed from Madagascar and Mauritius eastward through the Indian and Pacific oceans to Samoa, and from southern Japan and the Ryukyu Islands south to northern Australia and New Caledonia. Not reported from Hawaii.

Conus pulicarius Hwass, 1792.

Hirase and Taki (1951) pl. 113, fig. 11; Tinker (1952) p. 36, 2 figs. on p. 37; Morris (1952) p. 203, col. pl. 7, fig. 2; Kira (1955) pl. 36, fig. 15.

Characteristically 1.25 to 2.25 inches long, coronate, and white with numerous dark brown dots.

Ordinarily lives below low tide line along sandy lagoon shores, on sandy seaward reef slopes, and in sand pockets on seaward and lagoon reef flats. The recent Micronesian collections contain the following specimens:

[3] An endemic Hawaiian cone, *C. abbreviatus* Reeve, 1843 [Tinker (1952), figs. on p. 41], is closely related to both *C. miliaris* and *C. coronalis*. It is medium in color, covered with small distinct brown dots in regular rows, without flammules, but with dark-brown in the aperture. It is recorded only from Midway to the Hawaiian Islands.

four lots taken among turtle grass and small reefs in 2 to 5 feet of water on the sandy lagoon shelf at Ifaluk; several specimens from off the seaward reef edge at Bikini in 36 to 90 feet of water; and a number of shells found below low tide line on lagoon reef flats at Eniwetok. USNM specimens from Hawaii were collected on seaward reef flats and off the edge of seaward reefs to a depth of 300 feet. *C. pulicarius* ordinarily remains buried during the day, characteristically about 2 to 4 inches beneath the sand, and moves about only at night.

GEOGRAPHIC RANGE: USNM collections of this common Indo-Pacific species are from Cocos-Keeling Atoll in the Indian Ocean eastward through the Pacific to the Society, Tuamotu, and Marquesas islands, and from southern Japan south to New Caledonia. Reported from northern Australia and from Hawaii.

Conus quercinus Hwass, 1792 (syn. *cingulum* Martyn, 1786, nonbinom.).

Tinker (1952) p. 28, 5 figs. on p. 29; Morris (1952) p. 202, col. pl. 7, fig. 12; Kira (1955) pl. 37, fig. 7.

Characteristically 1.25 to 4 inches long, although Hawaiian specimens occasionally attain a length of 5 inches.

The recent Micronesian collections include only one specimen obtained at Onotoa from a native and without specific locality data. According to Greene (1953), this species lives in groups and is seldom found in less than 20 feet of water.

GEOGRAPHIC RANGE: USNM collections and published records indicate distribution from the east African coast (including the Red Sea and Persian Gulf), eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan and Hawaii south to the East Indies and New Caledonia. Not reported from Australia. Uncommon in Micronesia.

Conus rattus Hwass, 1792.

Tinker (1952) p. 38, 2 figs. on p. 39; Morris (1952) p. 202, col. pl. 7, fig. 14; Kira (1955) pl. 36, fig. 19.

Characteristically 0.75 to 1.75 inches long.

Ordinarily lives near low tide line under rocks and in rocky tide pools on windward and leeward ocean reef flats. Also taken from lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections and published records indicate distribution of this common Indo-Pacific cone from South Africa and the Red Sea eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus sponsalis Hwass, 1792.

Kira (1955) pl. 36, fig. 12.

FIG. 41. *Conus sponsalis* Hwass. Ifaluk Atoll, Caroline Islands (USNM 614194).

Characteristically 0.5 inch to slightly less than 1 inch long. Body whorl typically smooth above and spirally granulate below; white with dark brown, elongate, spirally arranged, axial flammules; and covered with a yellowish epidermis. Spire coronate. Aperture purple within.

Ordinarily lives among rocks on windward and leeward ocean reef flats, generally at or near low tide line or in tide pools. Apparently less abundant on lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections and published records indicate this common Micronesian cone to be distributed from Mauritius throughout the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan south to northern Australia and New Caledonia. Not reported from Hawaii.

Conus striatus Linné, 1758.

Tinker (1952) p. 32, fig. on p. 33; Morris (1952) p. 199, col. pl. 7, fig. 1; Kira (1955) pl. 37, fig. 9.

Characteristically 2 to 4 inches long.

Only two specimens in the recent Micronesian collections were taken alive; one from the reef at the east side of Tomil Harbor, Yap, and the other from among small reefs on the sandy lagoon shelf at Ifaluk. Like many cones it is poisonous. Nocturnal.

GEOGRAPHIC RANGE: USNM collections and published records for this uncommon Indo-Pacific cone indicate distribution from East Africa (including the Red Sea and Persian Gulf) eastward through the Indian and Pacific oceans to the Society, Tuamotu, and Marquesas islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia. Uncommon in Micronesian collections, but may be locally abundant in some parts of the Indo-Pacific.

Conus textile Linné, 1758.

Hirase and Taki (1951) pl. 114, fig. 15; Tinker (1952) p. 36, fig. on p. 37; Morris (1952) p. 199, col. pl. 7, fig. 19.

Characteristically 1.25 to 4.75 inches long.

The only specimen of *C. textile* in the recent Micronesian collections is a worn specimen from Puntan Muchot beach, leeward Saipan. Abbott (1950) reports that this species occurs on the outer shores of the main atoll at Cocos-Keeling. Instances of fatal poisoning from the bite of *C. textile* have been reported. The species is nocturnal.

GEOGRAPHIC RANGE: USNM collections and published records indicate this well-known but uncommon Indo-Pacific cone to be distributed from East Africa (including the Red Sea and Persian Gulf) eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus tulipa Linné, 1758.

Hirase and Taki (1951) pl. 114, fig. 18; Kira (1955) pl. 37, fig. 19.

Characteristically 1.25 to 3.25 inches long.

Ordinarily lives under rocks and coral on seaward reef flats, but also found on lagoon reef flats. *C. tulipa* has a poisonous bite. Nocturnal.

GEOGRAPHIC RANGE: USNM collections and published records indicate this rather common Micronesian species to be distributed from the Red Sea, the Seychelles, and Madagascar eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Conus vexillum Gmelin, 1791.

Hirase and Taki (1951) pl. 114, fig. 6 [poor].

Characteristically 1.75 to 4.75 inches long, occasionally reaching a length of 6 inches.

The recent Micronesian collections contain only one specimen taken alive. It was found on the shallow seaward reef flat of leeward Onotoa. Abbott (1950) reports that a single specimen was found living on the outer shores of Cocos-Keeling Atoll.

GEOGRAPHIC RANGE: USNM collections and published records indicate this uncommon Indo-Pacific species to be distributed from the Red Sea, Madagascar, and Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to New South Wales and New Caledonia.

Conus virgo Linné, 1758.

Hirase and Taki (1951) pl. 114, fig. 10; Kira (1955) pl. 37, fig. 10.

Characteristically 1.75 to 4 inches long.

The recent Micronesian collections contain only one specimen. It was found living in 3 or 4 feet of water on the leeward ocean reef flat of Onotoa.

GEOGRAPHIC RANGE: USNM collections and published records indicate distribution

from the east African coast (including the Red Sea) eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia. Uncommon in Micronesia.

Conus vitulinus Hwass, 1792.

Tinker (1952) p. 36, fig. on p. 37; Morris (1952) p. 202, col. pl. 7, fig. 17.

Characteristically 1 to 2.25 inches long.

Ordinarily lives among rocks and in tide pools on seaward reef flats. Also reported from lagoon reef flats.

GEOGRAPHIC RANGE: USNM collections and published records indicate this uncommon Indo-Pacific species to be distributed from Madagascar and Mauritius eastward through the Indian and Pacific oceans to the Society and Tuamotu islands; and from southern Japan and Hawaii south to northern Australia and New Caledonia.

Family TEREBRIDAE—Auger Shells

Genus TEREBRA Bruguière, 1789

Terebra crenulata (Linné, 1758).

Hirase and Taki (1951) pl. 116, fig. 10; Tinker (1952) p. 10, 3 figs. on p. 11; Kira (1955) pl. 38, fig. 16.

Characteristically 5 to 6 inches long and whitish or fawn-colored with crenulated sutures.

Ordinarily lives buried a few inches in the sand of lagoon shelves, in quiet shallow water, or in intertidal lagoon sand flats.

GEOGRAPHIC RANGE: According to USNM records this common Micronesian species is distributed from Cocos-Keeling Atoll eastward through the Pacific to Palmyra Atoll and Samoa, and from southern Japan south to the New Hebrides. Reported from the Red Sea, Persian Gulf, and Madagascar through the Indian and Pacific oceans to the Tuamotu and Marquesas islands, from Hawaii, and from northern Australia.

Terebra dimidiata (Linné, 1758).

Hirase and Taki (1951) pl. 116, fig. 3; Tinker (1952) p. 14, fig. on p. 17; Kira (1955) pl. 38, fig. 17.

Characteristically 4 to 6 inches long, white with squarish orange markings on each whorl, and with a distinct spiral groove below each suture.

Habitat similar to that of *T. crenulata*.

GEOGRAPHIC RANGE: USNM collections of this common Micronesian *Terebra* range from Mauritius eastward through the Indian and Pacific oceans to the Hawaiian and Tuamotu islands, and from the Ryukyu Islands south to the Solomon and Fiji islands. It is reported from East Africa, Madagascar, the Seychelles, and Ceylon, from southern Japan, and from northern Australia.

Terebra felina (Dillwyn, 1817) (syn. *tigrina* Gmelin 1791 [in part]).

Hirase and Taki (1951) pl. 116, fig. 9; Tinker (1952) p. 22, 2 figs. on p. 23 [as *T. tigrina* Gmelin]; Morris (1952) p. 198, pl. 40, fig. 7 [as *T. tigrina* Gmelin].

Characteristically less than three inches long and white with orange-brown spots and incised spiral grooves below each whorl.

The only specimen in the recent Micronesian collections was found living in shallow, quiet water on the sandy lagoon shelf of leeward Ifaluk.

GEOGRAPHIC RANGE: USNM collections are from the Ryukyu, Philippine, Caroline, and Marshall islands. Reported from East Africa, the Seychelles, Madagascar, Mauritius, New Caledonia and the Loyalty Islands, from Hawaii, and from northern Australia. Uncommon in Micronesia.

Terebra guttata (Röding, 1798) (syn. *oculata* Lamarck, 1822).

Hirase and Taki (1951) pl. 116, fig. 2 (as *T. oculata* Lamarck); Tinker (1952) p. 12, fig. on p. 13 (as *T. oculata* Lamarck); Kira (1955) pl. 38, fig. 20.

Characteristically about five inches long and orange or fawn-colored with a single row of white spots below each suture.

Habitat similar to that of *T. maculata*, *T. dimidiata*, and *T. crenulata*. Also, Allan (1950) reports this species living in sand on coral reefs.

GEOGRAPHIC RANGE: USNM collections are from the East Indies eastward throughout the Pacific to the Society Islands, and from the Philippine and Mariana islands south to Fiji. Uncommon in Micronesia. Reported from the Ryukyus, northern Australia, and Hawaii.

Terebra maculata (Linné, 1758).

Hirase and Taki (1951) pl. 116, fig. 7; Tinker (1952) p. 12, fig. on p. 13; Morris (1952) p. 197, pl. 40, fig. 2; Kira (1955) pl. 38, fig. 21.

The largest Indo-Pacific *Terebra*, characteristically 6 to 8 inches long. White or flesh-colored with dark brown or purplish splotches.

Like *T. crenulata* and *T. dimidiata*, *T. maculata* is ordinarily found buried a few inches in the sand of lagoon shelves, in quiet shallow water, or in lagoon sand flats which are exposed at extreme low tide.

GEOGRAPHIC RANGE: USNM collections of this very common Micronesian *Terebra* are distributed from East Africa eastward through the Indian and Pacific oceans to the Hawaiian and Society islands, and from the Ryukyu and Bonin islands south to New Caledonia. It is also reported from the Persian Gulf, the Red Sea, India, and Ceylon, from southern Japan, and from northern Australia.

Terebra striata Quoy and Gaimard, 1833 (syn. *affinis* Gray, 1834).

A small species, characteristically 1 to 1.5 inches long. White with brown transverse streaks and numerous, closely spaced, incised transverse grooves. A spiral groove is present below each suture.

Ordinarily found buried in the sand of lagoon shelves in shallow, quiet water or in lagoon sand flats which are exposed at extreme low water. Also found, though less frequently, in sand pockets between coral patches on seaward reef flats.

FIG. 42. *Terebra striata* Quoy and Gaimard. Composite drawing of two specimens from Ifaluk Atoll, Caroline Islands (USNM 614196).

GEOGRAPHIC RANGE: USNM collections are from the Ryukyu, Philippine, Mariana, Caroline, Marshall, Gilbert, Fiji, Cook, Society, and Tuamotu islands. Although *T. striata* is uncommon in most Micronesian collections, the recent ones include several specimens. Not reported from Hawaii.

Terebra subulata (Linné, 1758).

Hirase and Taki (1951) pl. 116, fig. 1; Tinker (1952) p. 12, fig. on p. 13; Morris (1952) p. 197, pl. 40, fig. 4; Kira (1955) pl. 38, fig. 19.

Characteristically 4 to 6 inches long and whitish with three rows of squarish dark brown spots on its body whorl.

Habitat similar to that of *T. maculata*, *T. crenulata*, and *T. dimidiata*. In addition, Allan (1950) reports this species to be abundant in sand pockets on the reefs of northern Australia.

GEOGRAPHIC RANGE: USNM collections are from the East Indies eastward throughout the Pacific to the Hawaiian and Tuamotu islands, and from the Ryukyu Islands south to New Caledonia. Reported from East Africa, the Red Sea, Ceylon, the Andaman Islands, and

northern Australia. Fairly common in Micronesia.

REFERENCES

ABBOTT, R. T. 1949. Samoa—shell-collector's paradise. *Sci. Monthly* 69(5): 319–327, 6 illus.

——— 1950. The molluscan fauna of the Cocos-Keeling Islands, Indian Ocean. *Raffles Mus., Singapore, Bul.* 22: 68–98.

——— 1951. In search of the golden cowrie. *Nat. Hist. Mag.* 60(3): 104–110, 9 illus.

ALLAN, JOYCE. 1950. *Australian Shells.* 470 pp. Georgian House, Melbourne, Australia.

BOUGE, L. J., and PHILIPPE DAUTZENBERG. 1922. Mitridés de la Nouvelle-Calédonie et de ses Dépendances. *Jour. de Conchyliologie* 67: 83–259, 2 pls.

CLENCH, W. J., and YOSHIO KONDO. 1946. The poison cone shell. *Harvard Univ. Mus. Compar. Zoöl., Occas. Papers on Mollusks* 1(7): 49–80, 5 pls.

DAUTZENBERG, PHILIPPE. 1935. Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaisee. Gastéropodes Marins. Terebridae et Mitridae. *Brussels Mus. Roy. d'Hist. Nat., Mém.* (*hors Serie*) 2(17): 1–208, pls. 1–4.

——— 1937. Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaisee. Gastéropodes Marins. Conidae. *Brussels Mus. Roy. d'Hist. Nat., Mém.* (*hors Serie*) 2(18): 5–284, pls. 1–3.

DEMOND, JOAN. 1954. A key to the Hawaiian Cypraeidae. *Nautilus* 67(3): 86–90.

EDMONDSON, C. H. 1946. *Reef and Shore Fauna of Hawaii.* Bernice P. Bishop Mus., Spec. Pub. 22: 1–381.

FAUSTINO, L. A. 1928. Summary of Philippine marine and fresh-water mollusks. *Philippine Dept. Agr. and Nat. Resources, Bur. Sci., Monog.* 25: 1–384.

FREEMAN, O. W., and COAUTHORS. 1951. *Geography of the Pacific.* 573 pp. John Wiley and Sons, Inc., New York.

GREENE, K. W. 1953. "The genus *Conus* in the Hawaiian area." (Unpublished mimeographed list.) Board of Public Parks and Recreation, Honolulu, Hawaii.

HERTLEIN, L. G. 1937. A note on some species of marine mollusks occurring both in Polynesia and the Western Americas. *Amer. Phil. Soc., Proc.* 78(2): 303–312.

HERTLEIN, L. G., and W. K. EMERSON. 1953. Mollusks from Clipperton Island, Eastern Pacific, with the description of a new species of gastropod. *San Diego Soc. Nat. Hist., Trans.* 11(13): 345–364, pls. 26, 27.

HIRASE, SHINTARO, and ISAO TAKI. 1951. *A Handbook of Illustrated Shells in Natural Color from the Japanese Islands and Their Adjacent Territories.* 134 pls. Bunkyokaku, Tokyo, Japan.

HIRO, FUJIO. 1936. Notes on the molluscan fauna of Palau. Parts I and II: *Venus* 6(1 and 4): 31–43 & 208–221. (Japanese-English translation by Riuji Endo, published 1951 by Pacific Geological Surveys, Military Geology Branch, U. S. Geological Survey.)

INGRAM, W. M. 1947. Hawaiian Cypraeidae. *Bernice P. Bishop Mus., Occas. Paper* 19(1): 1–23.

——— 1948. The Cypraeid fauna of the Galapagos Islands. *Calif. Acad. Sci., Proc. Ser.* 4, 26(7): 135–145.

——— 1951. The living Cypraeidae of the Western Hemisphere. *Bul. Amer. Paleontol.* 33(136): 5–46, pls. 1–4.

KIRA, TETSUAKI. 1955. *Coloured Illustrations of the Shells of Japan.* 204 pp. Hoikusha, Osaka, Japan.

KURODA, TOKUBEI. 1941. A catalogue of molluscan shells from Taiwan (Formosa), with descriptions of new species. *Taihoku Imp. Univ., Faculty Sci. and Agr., Mem.* 22(4), *Geology* no. 17: 65–216, pls. 8–14.

KURODA, TOKUBEI, and TADASHIGE HABE. 1952. *Check List and Bibliography of the Recent Marine Mollusca of Japan.* 210 pp. Edited and published by Leo W. Stach, Box 121, Tokyo, Japan. Printed by Hosokawa Printing Co., Tokyo, Japan.

MARTENS, EDUARD VON. 1880. Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen. Mollusken. Extr. Möbius, *Reise nach Mauritius*, pp. 181–352, pls. 19–22. Berlin.

MELVILL, J. C., and ROBERT STANDEN. 1901. The mollusca of the Persian Gulf, Gulf of Oman, and Arabian Sea, as evidenced mainly through the collections of Mr. F. W. Townsend, 1893–1900; with descriptions of new species. Part I, Cephalopoda, Gastropoda, Scaphopoda. *Zool. Soc. London, Proc.* 2: 327–460, pls. 21–24.

MORRIS, P. A. 1952. *A Field Guide to Shells of the Pacific Coast and Hawaii.* 220 pp. Houghton Mifflin Co., Boston.

OSTERGAARD, J. M. 1950. Spawning and development of some Hawaiian marine gastropods. *Pacific Sci.* 4(2): 75–115, 42 figs.

PLATT, RUTHERFORD. 1949. Shells take you over world horizons. *Natl. Geog. Mag.* 96 (1): 33–84, 16 illus., 41 pls.

RAO, H. S. 1939. *Consolidated Report on the Shell-fisheries in the Andamans during the Years 1930–35.* Zool. Survey of India, pp. 1–130, pls. 1, 2. Calcutta.

SCHILDER, F. A., and M. SCHILDER. 1938. Prodrome of a monograph on living Cypraeidae. *Malacological Soc. London, Proc.* 23 (pts. 3 and 4): 119–231.

TALAVERO, FLORENCIO, and L. A. FAUSTINO. 1931. Industrial shells of the Philippines. *Philippine Jour. Sci.* 45(3): 321–350, pls. 1–18.

THIELE, JOHANNES. 1929. *Handbuch der Systematischen Weichtierkunde.* Vol. 1. 376 pp., 470 figs. Verlag von Gustav Fisher in Jena.

——— 1931. *Handbuch der Systematischen Weichtierkunde.* Vol. 2. 402 pp., 313 figs. Verlag von Gustav Fischer in Jena.

TINKER, S. W. 1949. The Hawaiian tun shells. *Pacific Sci.* 3(4):302–306.

——— 1952. *Pacific Sea Shells.* 230 pp. Mercantile Printing Co., Honolulu, Hawaii.

TRACEY, J. I., JR., K. O. EMERY, and P. E. CLOUD, JR. 1955. Conspicuous features of organic reefs. *Atoll Res. Bul.*, no. 46, 3 pp., 2 figs. [Mimeo.]

UTINOMI, HUZIO. 1952. *Bibliography of Micronesia.* 157 pp. Translated by O. A. Bushnell and others at the University of Hawaii. Univ. of Hawaii Press, Honolulu, Hawaii.

YONGE, C. M. 1953. Observations on *Hipponix antiquatus* Linnaeus. *Calif. Acad. Sci., Proc., Ser.* 4, 28(1): 1–24, 9 figs.

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A New Mosquito from Fiji, *Aëdes (Finlaya) freycinetiae* n. sp. (Diptera: Culicidae)

MARSHALL LAIRD[1]

UNTIL Marks (1947) described *Aëdes* (*Finlaya*) *fijiensis* from Viti Levu, it had been generally accepted that the representative of the widespread *kochi* group occurring there was *A. kochi* (Dönitz) itself. The easternmost limit of the latter species is now placed at, or at all events near, Nissan Island, Territory of New Guinea (Marks, 1947). The only indication that *A. fijiensis* may not be the sole member of its subgenus occurring in Fiji is Marks' (1947) brief account of a single distinctive larva—which she queried as perhaps referable to *A. samoanus* (Grünberg)—collected from *Pandanus* axils in association with *A. fijiensis*. There are no records of the latter species from outside of Fiji, but *A. samoanus* is found in Tonga as well as Samoa (Edwards, 1926) and Iyengar (1955) has recently listed it from the Wallis Islands. These two mosquitoes are the most easterly representatives of their subgenus thus far described from the South Pacific.

Paine (1943) considered leaf axils of the common coastal *Pandanus tectorius* (Sol.) to be the usual larval habitat of *A. fijiensis* (= *A. kochi* in part). He also reported this insect from the smaller *Pandanus thurstonii* Wright, and, less frequently still, from the large aroid *Alocasia indica*. Neither Amos (1947) nor Marks (1947) listed any additional larval habitats, Marks (presumably following Paine in Edwards, 1935) mistakenly referring *A. indica* to the genus *Colocasia*.

Whilst *A. fijiensis* is primarily associated with *Pandanus*, the larvae of *A. samoanus* occur most commonly in the leaf axils of *Alocasia* and *Colocasia* (Buxton and Hopkins, 1927). The latter authors never found *A. samoanus* larvae in axils of *Pandanus*, wild *Canna*, and pineapples as did O'Connor (1923); neither did they ever collect them from tree holes or other small simple containers. However, Knight (in Bohart and Ingram, 1946) recorded *A. samoanus* from *Pandanus* in Samoa, and Laird (1956) took a few larvae from the axils of a large *Pandanus* in Tonga and a few others from a small tree hole (a step in a coconut palm trunk) near Apia, Samoa.

Finlaya larvae were collected from *Freycinetia* leaf axils, a new habitat for mosquitoes of this subgenus (c.f. Knight and Marks, 1952), during field studies in Fiji early in 1954 (Laird, 1956). The species concerned proved to belong to the *kochi* group, coming closest to *A. samoanus* but differing in detail from this insect, *A. fijiensis*, and other members of the group as described herein.

ACKNOWLEDGMENTS

The Fijian and Tongan collections to which reference is made were undertaken with the help of my wife, and Dr. L. F. Jepson of the Health Department, Western Samoa, rendered valuable assistance at Apia. I am grateful to Mr. J. Parham of the Department of Agriculture, Fiji, for his identification of *Freycinetia milnei* Seem. All material was collected in the course of mosquito studies initiated by the Royal New Zealand Air Force and supported by a grant from the N. Z. Department of Scientific and Industrial Research.

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MATERIAL

Four larval collections of *Aëdes freycinetiae* n. sp. were made, all of them from a forest climbing plant belonging to the family Pandanaceae, *Freycinetia milnei* Seem. The first location was at an altitude of 125 m. near the Glen Pool, Suva (March 1, 1954), and the other three were at varying altitudes near 1,000 m. in the vicinity of Nandarivatu, northern Viti Levu (March 8 and 9). Larvae were rare in all cases, no more than three ever being taken from a single axil. Collections from 122 successive axils (Glen Pool) produced an average of only 0.12 larvae per axil (av. water content, 1.23 cc.). Ecological data concerning the larval habitat have already been published (Laird, 1956).

Fourth instar larvae brought back to the laboratory did not pupate for up to eight days, and the duration of the pupal stage ranged from 45 to 50 hours. A small series of males and females was obtained. There was no opportunity to describe them at the time, as the laboratory equipment was being crated preparatory to our departure from Fiji, which took place a few weeks after these collections were made. Most unfortunately, an accident en route to New Zealand resulted in the total destruction of the pinned specimens. However, the larval slides and two alcohol-preserved adults, a male and a female, survived. It is not practicable to attempt a full description of the adults from the balsam mounts prepared from these specimens, details of colouring and scaling having been obscured in varying degree. A complete account of this insect must await further collections, but the male genitalia and the larvae are sufficiently distinctive to warrant the description of a new species at this stage.

Aëdes (*Finlaya*) *freycinetiae* n. sp.

TYPES: Holotype male, allotype female, and seven morphotype larvae, Glen Pool, Suva, March 1, 1954.

LOCATION OF TYPE MATERIAL: Holotype male, allotype female and two morphotype larvae in the collection of the Dominion Museum, Wellington; three morphotype larvae in the collection of the University of Queensland; and two morphotype larvae in my own collection.

ADULT: Wing length of holotype male, c. 2.5 mm., and of allotype female, 3 mm. The terminology used by Marks (1947) is employed in the following description. Wing (allotype female) with extensive clear areas and clothed with broad scales; *C* having the basal pale area continuous with confluent humeral and prehumeral pale areas; sector pale area little more than half the length of the preceding dark spot; subcostal pale area two-thirds the length of the preceding dark spot, and only separated from accessory subcostal pale area by a single dark scale (both wings); apical pale area separated from accessory subcostal pale area by a few scattered dark scales; cell R_2 three times length of stem; otherwise generally comparable with wing of *A. samoanus* as described by Marks (1947).

Abdominal sternites VI and VII each bordered apically by outstanding dark scales. The banding of tarsi, tibiae and femora characteristic of the *kochi* group, but details indeterminate in balsam mounts.

In the holotype male the palps are longer than the proboscis by rather more than the length of the apical segment. The genitalia are as follows:

Outer face of coxite dark scaled, about twice as long as broad; somewhat beyond the centre of the inner margin are two parallel lines of tubercles from which originate 14 lanceolate and dark coloured scales, the most distal ones long and narrow and the medial and proximal ones shorter and relatively broader (Fig. 1); bordering this scale tuft tergally is a prominent patch of about 25 setae (location indicated diagramatically in Fig. 2 A) each about half the length of the medial scales of the tuft; there are scattered curved or apically bent setae distally (Fig. 2 C), and there is a prominent patch of 75–80

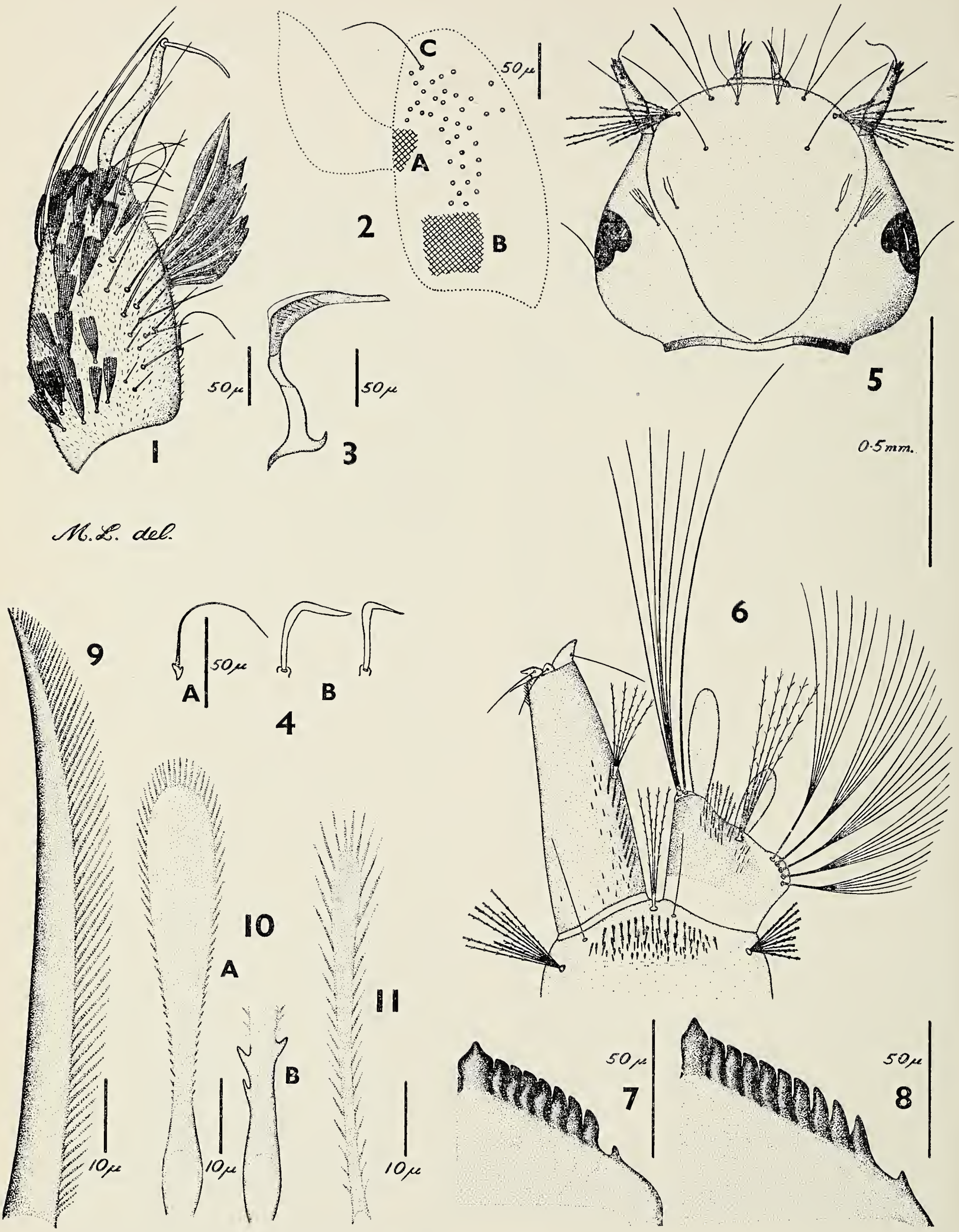

PLATE OF FIGURES 1 – 11

medially directed setae of this type (location indicated diagramatically in Fig. 2 B); an irregular double row of elongate straight or slightly curved setae extends down the sternal face of the coxite, whilst on the inner sternal edge, and at about one-quarter of the length of the coxite from its base, a bent, slender and inconspicuous specialized seta arises from a prominent tubercle (Figs. 1, 4 A); no subterminal setae are borne by the curved and slender style, which is about twice the length of its terminal appendage (Fig. 1); the appendage of the harpago is sharply pointed and broadly triangular (Fig. 3), and the paraproct has a single tooth.

LARVA: Very pale, the head and siphon lightly chitinized and the thorax and abdomen bearing stellate setae. Antenna non-spiculate, the tuft a single simple seta of rather more than half the length of the antenna and inserted at about the apical one-third; a long and sinuous subterminal seta ventrally (Fig. 5). Clypeal spine double. Head seta A stellate, posterior to B and d, and having from 9 to 13 frayed branches with forked tips, the longest branch being half as long again as the antenna; d and B two- or three-branched and simple, d rather shorter than B which exceeds the antenna in length; B originating in front of d, and these two setae a little closer to one another than B is to A; C an elongate simple seta originating behind the level of the base of the antenna and more or less in line with B; e with two branches and f three- or four-branched, the branches of these setae being simple and about as long as the clypeal spines (Fig. 5). Mentum (Fig. 7) with a stout medial tooth and eight smaller lateral teeth, the most basal of which is minute and widely separated from its nearest neighbour.

Abdominal segments I to VI each bearing a pair of long and plumose lateral setae, those of segment I being 8- to 10-branched, those of II 7- to 9-branched and those of III to VI 2-branched.

The lateral comb is a broadly triangular patch of from 70 to 80 scales in four irregular rows (Fig. 6), those of the distal row numbering from 14 to 16 and measuring some 65μ in length; these scales (Fig. 10, A), which are spatulate and fringed both laterally and apically, altogether lack lateral spines; the scales of the other rows are similar but shorter; two or three uneven lines of minute setae are located in front of the proximal row (Fig. 6).

The first and fifth pentad hairs are stellate, the frayed branches ranging from 8 to 12 in number and having forked tips; both the second and fourth pentad hairs are single and simple, while the third is four-branched and plumose (Fig. 6). The siphonal index is about 2.5 to 3.0, the siphon itself being bare except for sparse spicules basally and bordering the pecten, and an apico-dorsal patch (Fig. 6). There are from 8 to 11 pecten spines, the

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EXPLANATION OF THE PLATE

(All figures prepared by means of a Zeiss-Winkel drawing apparatus.)

FIG. 1. Outer aspect of male coxite, *A. freycinetiae*.

FIG. 2. Inner aspect of male coxite, *A. freycinetiae* (diagrammatic). A, location of patch of setae tergal to scale tuft. B, location of basal patch of setae. C, an apically bent seta.

FIG. 3. Harpago, *A. freycinetiae*.

FIG. 4. A, specialized seta of male coxite of *A. freycinetiae*. B, specialized setae of male coxite of *A. samoanus* (after Stone and Bohart, 1944).

FIG. 5. Larval head, *A. freycinetiae*.

FIG. 6. Terminal segments of abdomen, larva of *A. freycinetiae*.

FIG. 7. Mentum (teeth of one side only), larva of *A. freycinetiae*.

FIG. 8. Mentum (teeth of one side only), larva of *A. samoanus*.

FIG. 9. Pecten spine, larva of *A. freycinetiae*.

FIG. 10. A, scale of distal row of lateral comb, larva of *A. freycinetiae*. B, base of scale of distal row of lateral comb, larva of *A. samoanus*.

FIG. 11. Apical scale of anal segment, larva of *A. freycinetiae*.

distal three of which are rather more widely spaced than the others; these spines (Fig. 9) are finely fringed along the proximal edge and range from 80 μ to 95 μ in length. The subventral tuft has five plumose branches, and originates just beyond the middle of the siphon.

A lightly chitinized saddle covers the dorsal two-thirds of the anal segment; it is not pilose, but bears numerous fringed scales distally (Fig. 6); the apical scales (Fig. 11) are the longest, ranging up to 75 μ in length. The plumose lateral seta is four- or five-branched, the ventral brush consists of two parallel rows of five tufts each having six branches, and the caudal setae—the upper of which has six branches while the lower is single—are simple. Dorsal pair of anal papillae longer than ventral, ranging from little more than the length of the saddle to twice the length of the latter.

SYSTEMATIC POSITION

The spotted wings clothed with broad scales, the outstanding apical scales of abdominal sternites VI and VII, the banding of the legs, and the leaf axil habitat and stellate setae of the larvae all refer this *Finlaya* to the *kochi* group as defined by Marks (1947).

As previously stated, two representatives of this group are already known from Fiji and western Polynesia. These are easily differentiated from one another in both larval and adult states. The pale scales of the mesonotum are frosty white in *A. fijiensis* (as in *A. kochi* itself) and creamy to ochreous in *A. samoanus*; the male genitalia differ in several respects, the specialized seta of the coxite being broadly expanded medially in the former species and uniformly narrow in the latter one, the preapical tuft of the coxite consisting of 5 to 7 long and very narrow scales in *A. fijiensis* but of 10 to 12 long and broad scales in *A. samoanus*, and the style bearing subterminal setae in *A. fijiensis* alone; the larval siphon is pilose in the latter species (Marks, 1947) but bare, or only slightly pilose, in *A. samoanus* (Bohart and Ingram, 1946). In both insects the lateral comb scales have from two to four short lateral spines near the base (Fig. 10, B, *A. samoanus*).

The lack of any medial or other expansion of the threadlike specialized seta, the presence of 14 narrow and broad scales instead of only 5 to 7 narrow ones in the preapical tuft of the coxite, the absence of subterminal setae from the style, the presence of but few scattered spicules on the siphon and the complete absence of lateral spines from the comb scales, all combine to differentiate the *Finlaya* of *Freycinetia* axils from *A. fijiensis*. However, while the present species is at once distinguishable from *A. samoanus* by the absence of basal spines from the lateral comb scales, these two mosquitoes otherwise have much in common, and a closer comparison of their similarities and differences is indicated.

For the reasons already given, a full comparison of the adults cannot be made at present. The wing length of the females is similar, being 3.0 mm. in *A. freycinetiae* n. sp. and 3.0 mm. (Bohart and Ingram, 1946) to 3.2 mm. (Marks, 1947) in *A. samoanus* (that of *A. fijiensis* ranges from 2.7 mm. to 2.9 mm. according to Marks). There are, however, differences in venation. While Marks described the sector pale area of *C* as long in *A. samoanus*, this area is little more than half the length of the preceding dark spot in *A. freycinetiae* n. sp. The subcostal pale area of *C* is equal to or almost twice as long as the preceding dark spot in *A. samoanus*, but is only two-thirds the length of this spot in the present species; while the latter has cell R_2 three times the length of its stem, this cell varying from two to two-and-a-half times the length of its stem in *A. samoanus*.

Bohart and Ingram (1946) described the male palpi of *A. samoanus* as being about as long as the proboscis. These structures (which are slightly longer than the proboscis in *A. fijiensis*) exceed the proboscis by rather more than the length of the apical segment in *A.*

freycinetiae n. sp. There are significant differences between the male genitalia of the two mosquitoes. The preapical tuft of the coxite of *A. samoanus* is entirely composed of broad scales according to the data of Edwards (1935) and the figure of Bohart and Ingram (1946), but in *A. freycinetiae* n. sp. the distal scales are relatively much narrower in proportion to their length than the medial and proximal ones. Edwards (1935) gave the number of scales in the tuft of the former insect as 10 to 12, and Bohart and Ingram figured an example having 10, while the holotype ♂ of the latter species has 14. Although Edwards (1935) declared that the patch of setae tergal to the preapical tuft is scarcely indicated in *A. samoanus* by comparison with *A. fijiensis* (= Fijian *A. kochi*), this patch is equally prominent in the latter insect and *A. freycinetiae* n. sp. Considerable importance has been attached to the specialized seta in the classification of the *kochi* group. This seta is merely an apically bent hair hardly deserving the qualification of "specialized" in the Fijian insect under discussion; but although the specialized seta of *A. samoanus* was referred to as "very much shorter (than that of *A. fijiensis* . . . M. L.) and quite inconspicuous" by Edwards (1935), it was figured as a relatively broad structure by Stone and Bohart (1944; c.f. Fig. 4 B, herein) and Bohart and Ingram (1946).

Larval *A. samoanus* and *A. freycinetiae* n. sp. resemble one another but differ from *A. fijiensis* in the presence of but few scattered spicules on the siphon. Both the first-named species have a few spicules basally and laterally near the pecten, and also a prominent little apicodorsal line (neither referred to by previous authors who have discussed *A. samoanus* nor figured by Buxton and Hopkins, 1927, or Bohart and Ingram, 1946, but apparent in my material from Samoa and Tonga). Head hairs A, B and d arise in a curved line forwards in the case of *A. samoanus*, as was pointed out by Buxton and Hopkins (1927); this holds good in my Samoan and Tongan larvae, but in *A. freycinetiae* n. sp. d originates posterior to B (Fig. 5) as is the case in *A. fijiensis*. The general arrangement of the setae is otherwise much alike in the two species, although branching is more marked in *A. freycinetiae* n. sp.

The number, spacing, and shape of the pecten spines are comparable in *A. samoanus* and *A. freycinetiae* n. sp. It would seem from the literature that the former species has fewer comb scales ("perhaps fifty" according to Buxton and Hopkins, and "about 70" according to Bohart and Ingram) than the latter (70–80). Nevertheless, there are approximately 80 scales in the lateral comb of our *A. samoanus* larvae from Samoa and Tonga. However, the two insects are immediately separable

Seta	*A. freycinetiae* n. sp.	*A. samoanus*
Head		
Seta A	9–13 branches	4– 6 branches
Seta B	2– 3 branches	2– 3 branches
Seta C	Single	Single
Seta d	2– 3 branches	2– 4 branches
Seta e	2 branches	1– 2 branches
Seta f	3– 4 branches	2– 3 branches
Terminal segments		
1st pentad seta	8–12 branches	6–10 branches
2nd pentad seta	Single	Single
3rd pentad seta	4 branches	2– 3 branches
4th pentad seta	Single	Single
5th pentad seta	8–12 branches	6–10 branches
Siphonal subventral tuft	5 branches (all examples seen)	3–(rarely) 4 branches
Lateral seta of saddle	4– 5 branches	3– 4 branches

from one another by the shape of the comb scales of the distal row. In both cases these scales are long, spatulate and apically and laterally fringed (previous authors have described those of *A. samoanus* as apically fringed only, although the Samoan and Tongan specimens before me exhibit an extremely fine lateral fringe best seen by phase contrast illumination), but the prominent baso-lateral teeth of *A. samoanus* (Fig. 10, B) are altogether lacking in the Fijian insect in which the lateral fringe continues to the base (Fig. 10 A).

A final well-marked point of difference between the larvae of the two species is to be seen in the mentum. That of *A. samoanus* has from 19 to 21 teeth (Bohart and Ingram, 1946), all my Samoan and Tongan specimens being within this range and most of them exhibiting 10 teeth, the most basal one widely separated from the next, on each side of a larger, bullet-shaped medial tooth (Fig. 8). In every larva of *A. freycinetiae* n. sp. thus far examined, on the other hand, the mentum has only 17 teeth the medial one of which is relatively broader and squatter than is that of *A. samoanus* (Fig. 7).

It is considered that the morphological differences between the *Finlaya* of Fijian *Freycinetia* axils, and its closest relatives, are such as to require its description as new, and this insect is accordingly designated *Aëdes* (*Finlaya*) *freycinetiae* n. sp.

RELATIONSHIPS

The hairlike specialized seta of the coxite of the male of *A. freycinetiae* is quite distinct from that of *A. kochi*, *A. bougainvillensis* Marks, *A. fijiensis*, *A. wallacei* Edwards and *A. solomonis* Stone and Bohart, in all of which the apical portion is to some extent expanded. *A. samoanus* is the only other known member of the *kochi* group in which a specialized seta is present, and the form of the seta, together with other features of adult and larval morphology, indicates a close relationship between this species and *A. freycinetiae*. It is worth noting that *A. knighti* Stone and Bohart (Solomon Is.) is the only South Pacific member of the *kochi* group lacking a specialized seta altogether. None of the Oriental members of the group have such a seta (Knight and Laffoon, 1946). *A. knighti* is only known from three males from the New Georgia group, and although differing from *A. freycinetiae* in that the style is slightly inflated medially it resembles the latter insect in the absence of subterminal setae from this structure. From figure 7 of Stone and Bohart (1944) it would appear that the distal scales of the preapical tuft of the coxite are narrower than the medial ones as in *A. freycinetiae*. Further comparisons of the latter insect with *A. knighti* would be of decided interest.

The most striking single feature separating *A. freycinetiae* from *A. samoanus* is a larval one, the absence of baso-lateral spines from the lateral comb scales of the distal row. Marks (1947) and other authors have attached considerable significance to the shape of these scales in differentiating between species of the *kochi* group. In *A. kochi* itself and several other species of the group the distal comb teeth are pointed spines, not apically fringed scales, and Marks (1947) showed that, starting with the last-named insect "in New Guinea with the comb tooth having a stout, pointed medial spine and short lateral spines, as one passes eastwards the medial spine becomes longer and more slender, develops a flattened lateral flange, the thicker medial portion then becomes reduced, and finally the apex becomes rounded and fringed; the lateral spines persist throughout. Coming south from New Guinea, the medial spine remains stout and unflattened but the lateral spines are lost . . ." The Fijian *A. freycinetiae*, a species having spatulate and fringed comb scales, lacks any baso-lateral spines, just as do the two Australian species characterised by pointed comb spines, *A. alocasicola* Marks and *A. gahnicola* Marks.

One may question whether these baso-lateral spines have really been "lost" at all in the three species just referred to. From the

figures presented by Marks (1947) it appears that in all members of the *kochi* group, those having pointed comb spines distally as well as those having fringed scales only, the proximal rows of the comb consist exclusively of apically and laterally fringed scales. As, moreover, the pointed condition is least evident in the early instars, it may be postulated that the development of pointed spines in the distal row is a later development than that of fringed scales. Support for this hypothesis is to be derived from a wider study of the tribe Culicini. Some of the more "primitive" members of this tribe (e.g., *Toxorhynchites*, *Trichoprosopon*) lack a lateral comb altogether, others (e.g., *Harpagomyia*, *Theobaldia*) have a comb composed wholly of fringed scales, and for that matter the least specialized subgenera of individual genera often exhibit only fringed scales (e.g., *Maorigoeldia* of *Tripteroides*, *Mucidus* of *Aëdes*) although the comb of their more advanced relatives may consist partly or wholly of pointed spines. Again, in the subgenus *Culex*, generalized species such as *C. annulirostris* Skuse and *C. tritaeniorhynchus* Giles breed in a wide range of surface waters and their larvae have large numbers of small, fringed scales in the lateral comb; species which have clearly diverged from the generalized ancestral stock, on the other hand—for example *C. bitaeniorhynchus* Giles and *C. squamosus* Taylor, the larvae of which are to be found in association with green filamentous algae, and *C. basicinctus* Edwards, having larvae specialized for life amongst algae in flowing streams—have the lateral comb made up of relatively small numbers of pointed spines.

Accepting that the development of pointed spines in the distal row of comb teeth of members of the *kochi* group represents the specialization of a more generalized type of comb tooth, the fringed scale—and Marks (1947) noted that a larva of *A. kochi* itself from Nissan Island, at the eastern periphery of the range of this species, had one of the distal comb teeth apically fringed—there are good grounds for postulating that the development of baso-lateral spines on both types of teeth is likewise a specialization. Marks (1947) drew attention to the fact that the Philippine *A. flavipennis* (Giles) (which of all members of the *kochi* group exhibits least development of the larval specializations which characterize these insects) has only short scales with a rounded tip and a fine apical and lateral fringe in the distal row of the lateral comb. This may be viewed as being in accord with the general tendency for the more primitive representatives of the various animal groups to be found towards the periphery of the zone of dispersal, as may the distribution of the more southerly species of the *kochi* group lacking baso-lateral spines on the comb teeth, *A. alocasicola*, *A. gahnicola*, and *A. freycinetiae*.

The morphology of the last-named species, particularly the primitive type of fringed scale in the distal row of the larval lateral comb and the slender and scarcely specialized seta of the male coxite, suggests that this insect might be close to the parent stock from which both of its nearest relatives, *A. samoanus* and *A. fijiensis*, have evolved. This hypothesis gains weight from the fact that the larval habitat of *A. freycinetiae* is an indigenous forest plant in the axils of which the parent stock could well have persisted in ecological isolation long after an evolving sympatric species had invaded various large species of *Pandanus*. Species of *Freycinetia* and *Pandanus* form part of the indigenous Fijian flora, and ample time has thus been available for the development of the various morphological differences which at once separate *A. fijiensis* from *A. freycinetiae;* but much less time can have operated in the case of the closest relative of the latter species, *A. samoanus*, which customarily breeds in the axils of *Colocasia* and *Alocasia* spp., plants owing their distribution throughout the South Pacific to human agency.

Buxton and Hopkins (1927) found it "not easy to understand why the typical *A. kochi*, breeding in coco-nuts, should give rise to

this race (*A. samoanus* . . . M. L.) breeding so exclusively in the axils of taro, for coconut shells, and many other small dark hollows, are abundant in Samoa and Tonga." These authors also found it difficult to account for the limited distribution of *A. samoanus* in Polynesia. Their puzzlement disappears in the light of the information now available. In the first place, Buxton and Hopkins based their belief that *A. kochi* breeds in husks on a record from New Britain by Hill (1925, also in Edwards, 1926). More recent investigators have altogether failed to corroborate this, and Laird (1946) found *kochi* larvae only in *Colocasia* axils and in one *Pandanus* axil in New Britain. The larval habitats listed for this species by Marks (1947) and Knight and Marks (1952) were *Colocasia*, *Alocasia*, *Pandanus*, *Crinum*, bananas and pineapples; and various plants belonging to the families Araceae and Pandanaceae comprise the usual habitats of members of the *kochi* group in general. The second point considered anomalous by Buxton and Hopkins, the limited distribution of *A. samoanus* in Polynesia, ceases to be surprising when we can view this insect not as an ecologically and geographically isolated subspecies of *A. kochi* but as a sibling species, evolved in the South Pacific, which may have yet to attain its maximum limits of dispersal.

CONCLUSIONS

A. freycinetiae is regarded as close to the parent stock whence sprang *A. fijiensis* and *A. samoanus*, the last-named insect being much its closest relative. It remains to be established whether *A. samoanus* itself exists in Fiji. Despite the fact that great numbers of collections from various aroids, made over a considerable period of time, have not revealed its presence there, it is quite feasible that a race utilizing some other plant—perhaps a member of the Pandanaceae—as a larval habitat is yet to be discovered. This is all the more likely in view of the occasional occurrence of *A. samoanus* larvae in *Pandanus* axils in Samoa and Tonga and of Lever's discovery of a single distinctive larva associated with *A. fijiensis* in *Pandanus*. Marks (1947) gave a brief description of this larva, which, differing as it does from *A. fijiensis* in having a non-pilose siphon, and from *A. freycinetiae* in having distal comb teeth similar to those of the former species, is very likely referable to *A. samoanus*, as she suggested.

A careful investigation of the axils of *Freycinetia* spp. and other forest Pandanaceae in Samoa and elsewhere in the South Pacific, notably in the New Hebrides and New Caledonia whence no representatives of the *kochi* group are known, might well shed still further light upon our knowledge of these mosquitoes.

Observations on the biting habits of *A. freycinetiae* have yet to be made. Information concerning the behaviour of this insect is particularly desirable in view of the announcement by Symes (1955) that 68 (21.6 per cent) of 314 *A. fijiensis* females caught in houses and forest in Fiji (localities not stated) exhibited filarial infection (chiefly *Wuchereria bancrofti*). Symes' mosquito identifications having been made in the belief that but one species of the *kochi* group is to be found in Fiji, the occurrence there of a second species and perhaps a third one as well obviously has important bearing on his conclusions.

REFERENCES

AMOS, D. W. 1947. *Mosquito Control Training Manual*, pp. 1–44. Govt. Press. Suva.

BOHART, R. M., and R. L. INGRAM. 1946. *Mosquitoes of Okinawa and Islands in the Central Pacific*. U. S. Bur. Med. and Surg., U. S. Nav. Med. Bul. 1055. ii + 110 pp.

BUXTON, P. A., and G. H. E. HOPKINS. 1927. *Researches in Polynesia and Melanesia*. Parts I–IV. London School Hyg. and Trop. Med., Res. Mem. 1. xi + 260 pp.

EDWARDS, F. W. 1926. Mosquito Notes. VI. *Bul. Ent. Res.* 17: 101–131.

——— 1935. Mosquito Notes. XII. *Bul. Ent. Res.* 26: 127–136.

HILL, G. F. 1925. The distribution of anopheline mosquitoes in the Australian re-

gion, with notes on some Culicine species. *Roy. Soc. Victoria, Proc.* 37: 61–77.

IYENGAR, M. O. T. 1955. *Distribution of Mosquitoes in the South Pacific Region.* So. Pacific Comn., Tech. Paper 86. v + 47 pp. Noumea.

KNIGHT, K. L., and J. L. LAFFOON. 1946. The Oriental species of the *Aëdes* (*Finlaya*) *kochi* group. *Amer. Ent. Soc., Trans.* 72: 203–225.

KNIGHT, K. L., and E. N. MARKS. 1952. An annotated checklist of the mosquitoes of the subgenus *Finlaya*, genus *Aëdes*. *U. S. Natl. Mus., Proc.* 101: 513–574.

LAIRD, M. 1946. A report on material obtained during a mosquito survey at Palmalmal, New Britain. *Roy. Soc. New Zeal. Trans. and Proc.* 75: 465–478.

——— 1956. *Studies of Mosquitoes and Freshwater Ecology in the South Pacific.* Roy. Soc. New Zeal., Bul. 6. 213 pp. Wellington.

MARKS, E. N. 1947. Studies of Queensland mosquitoes. Part I. The *Aëdes* (*Finlaya*) *kochi* group with descriptions of new species from Queensland, Bougainville and Fiji. *Queensland Univ., Dept. Biol., Papers* 2: 1–66.

O'CONNOR, F. W. 1923. *Researches in the Western Pacific.* London School Hyg. and Trop. Med., Res. Mem. IV. iv + 57 pp.

PAINE, R. W. 1943. *An Introduction to the Mosquitoes of Fiji.* Fiji Dept. of Agr., Bul. 22. 35 pp. 2nd Ed., revised by R. J. A. W. Lever. Suva.

STONE, A., and R. M. BOHART. 1944. Studies on mosquitoes from the Philippine Islands and Australasia (Diptera, Culicidae). *Wash. Ent. Soc. Proc.* 46: 205–225.

SYMES, C. B. 1955. Filarial infections in mosquitoes in Fiji. *Roy. Soc. Trop. Med. and Hyg., Trans.* 49: 280–282; with comments by Sir Philip Manson-Bahr, pp. 282–284.

NEWS NOTE

The Second World Orchid Conference

The Second World Orchid Conference will be held in Honolulu, Hawaii, from September 19 to 23, 1957. Dr. J. H. Beaumont, of the University of Hawaii, is general chairman of the Joint Planning Committee. He is assisted by Dr. Gordon W. Dillon, of the Botanical Museum at Harvard University, as chairman of the Program Committee, and by Mr. Ben T. Kodama, of Honolulu, as chairman of the Conference Show Committee.

Primarily intended for comparison and observation of orchid culture techniques and for the exchange of information about orchids, the Conference is jointly sponsored by the University of Hawaii, the American Orchid Society, Inc., and the Hawaiian Orchid Societies, Inc., the central organization of all orchid associations in the Territory of Hawaii.

Authorities on amateur and professional orchid culture from the United States and the Orient will speak at the sessions of the Conference. Tours to some of the Hawaiian Islands' outstanding gardens, orchid nurseries, and points of interest are planned for more than 1,000 visitors to Hawaii who are expected to attend the Conference. Although the majority of these visitors will come from the continental United States, a large number will come from orchid-growing centers in South America, Europe, and Asia.

Approximately 1,500 registrants are expected to enter exhibits in the Orchid Show, which will be set up in the patios and galleries of the Honolulu Academy of Arts. The show will offer the best and most representative collection of orchids grown in the Hawaiian Islands and in other parts of the world. Nearly 2,000 Hawaii-grown plants, mostly of dendrobiums, vandas, and cattleyas, are to be included in the displays. Because Hawaii produces more vanda and dendrobium hybrids than does any other place in the world, this portion of the show will offer new varieties of uncommon interest to visitors.

Among anticipated foreign entries, mostly of cut flowers, will be miniature cymbidiums from Japan, new English hybrid cattleyas, cypripediums from France, and cooler-climate species from other European countries.

Cut flowers from continental United States and from Australia are expected to occupy a large part of the show. Additional galleries will display new species of dendrobium from Singapore and Thailand, general collections from the Philippines and East Indies, and cattleya species from Central and South America.

Manuscript form. Manuscripts should be typed on one side of standard-size, white bond paper and double-spaced throughout. Pages should be consecutively numbered in upper right-hand corner. Sheets should not be fastened together in any way, and should be mailed flat. Inserts should be either typed on separate sheets or pasted on proper page, and point of insertion should be clearly indicated.

Original copy and one carbon copy of manuscript should be submitted. The author should retain a carbon copy. Although due care will be taken, the editors cannot be responsible for loss of manuscripts.

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CRAWFORD, DAVID L. 1920*a.* New or interesting Psyllidae of the Pacific Coast (Homop.). *Ent. News* 31 (1): 12–14.

——— 1920*b.* Cerotrioza (Psyllidae, Homoptera). *Hawaii. Ent. Soc., Proc.* 4 (2): 374–375.

ROCK, JOSEPH F. 1916. The sandalwoods of Hawaii; a revision of the Hawaiian species of the genus *Santalum. Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry Bot., Bul.* 3: 1–43, 13 pls.

In the text, sources should be referred to by author, date, and page, as follows: "It was noted (Rock, 1916: 18) that . . ." or "Rock (1916: 21–24) says . . ."

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U P H

VOL. XI OCTOBER 1957 NO. 4

PACIFIC SCIENCE

AND PHYSICAL SCIENCES OF THE PACIFIC REGION
A QUARTERLY DEVOTED TO THE BIOLOGICAL

IN THIS ISSUE: Moore — *Species of* Xeronema • Wentworth — *Impact Scars at Kilauea* • Iversen and Yoshida — *Biology of Wahoo in the Line Islands* • Matthews — *Anomuran Non-pedunculate Spermatophores* • Marples — *Spiders from Pacific Islands, II* • Newell — *Studies on the Johnstonianidae* • Index

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(Continued on inside back cover)

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

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The Species of *Xeronema* (Liliaceae)

LUCY B. MOORE[1]

BRONGNIART AND GRIS (1864*a*) proposed the genus *Scleronema* to accommodate a species which they named *S. moorii* in honour of Mr. C. Moore, Director of the Botanic Gardens in Sydney, who had collected specimens from the mountains of New Caledonia. The name *Scleronema* was preoccupied (Bentham, 1862: 109) and within a few months Brongniart and Gris (1864*b*) substituted the name *Xeronema* and the New Caledonian plant became *X. moorii* (spelled *moorei* by later authors). A full and illustrated description of this species appeared four years later (Brongniart and Gris, 1868: 2–5, table 1), together with a discussion of its affinities. The genus *Xeronema* was considered monotypic until the discovery of *X. callistemon* on cliffs of the Poor Knights Islands off the east coast of North Auckland, New Zealand (Oliver, 1925: 383, 1926: 1–3). In 1933 Mr. A. T. Pycroft found the new species on Taranga or Hen Island, some 30 miles farther south (Cranwell, 1933: 234–36). Figure 1 shows the geography of these locations.

In drawing up his description of *X. callistemon* Oliver had at his disposal Brongniart and Gris's 1868 account and figures of *X. moorei* but no direct comparison of specimens of the two species seems to have been made until recently. In August 1953 Mr. L. J. Dumbleton, then of the South Pacific Commission in New Caledonia, kindly sent early and mature flowering stems collected from an altitude of 600 to 750 metres on Mont Mou, followed in June 1954 by a rooted fan and a head of mature capsules still containing a few seeds, collected from an altitude of 1,000 metres on Montagne des Sources on the main mountain chain near Noumea. These specimens confirm that the two species are amply distinct though undoubtedly congeneric, but there are good distinguishing characters other than those emphasized by Oliver. It seems worth while to review the differences and at the same time to record some further details about the New Zealand species.

ACKNOWLEDGEMENTS

The writer gladly expresses thanks to Mr. L. J. Dumbleton for the New Caledonian material on which comparisons were based; to Dr. W. R. B. Oliver for a copy of Brongniart and Gris's 1868 paper and figure and for other help; to Miss E. K. Pickmere (Mrs. W. Reynolds) for careful notes on garden plants; to Miss N. M. Adams for the drawings for Figure 4.

COMPARISON OF THE TWO SPECIES

The two species resemble each other in habit, with stiff iris-like bright green leaves borne in many short-stemmed fans (Figs. 2, 3). Leaf bases are very fleshy, making the plants drought-resistant, and in both species there is a distinct sinus just above the junction of sheath and blade; this sinus is not shown in Brongniart and Gris's figure and Oliver erroneously listed it amongst distinguishing characters of *X. callistemon*. The stout scape with its sheathing bracts carries the horizontal raceme well above the leaves. Flowers arise in the axils of bracts all round the raceme axis, but the pedicels of those on the under side elongate and bend upwards so that they are "toutes dirigées vers le ciel." The inflorescences seen show the same colour range in both species, being predominantly and persistently red (the pollen almost tangerine), with gradual change from bright to duller

[1] Botany Division, Department of Scientific and Industrial Research, Wellington, New Zealand. Manuscript received August 10, 1956.

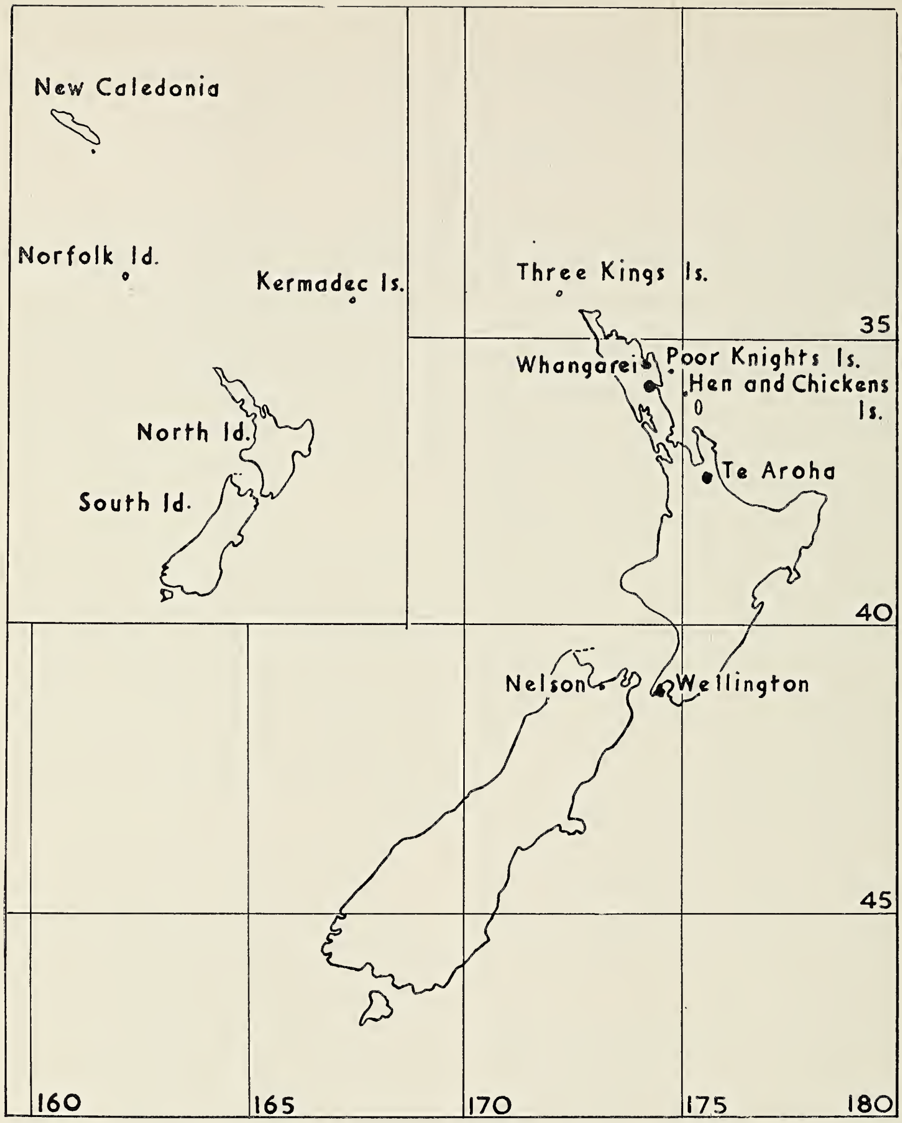


FIG. 1. Map of New Zealand showing places mentioned in text. Inset indicates position of New Caledonia in relation to New Zealand.

tones as the capsules ripen. *X. callistemon* shows a wide diversity in size, leaves reaching more than a metre and racemes up to 30 cm. in length; on the other hand plants 30 cm. tall can bear racemes only 10 cm. long both on exposed ridges on the islands and under comparable garden conditions. Dimensions given for *X. moorei* are nearer this minimum but it is uncertain whether the difference in size is at all significant; as a matter of convenience smallish plants and inflorescences might have been chosen for sending to herbaria. Thus vegetatively the two species would be difficult to distinguish from each other, and the flowering heads are much alike in general appearance.

Floral structures show good diagnostic characters. As Oliver pointed out, the tepals of the inner whorl in *X. callistemon* are narrower than the outer ones, whereas in *X.*

moorei they are all similar (Fig. 4A, D). Differences in capsule shape were emphasized by Oliver and are shown in Figure 4B, E; New Zealand capsules are more strongly stipitate than those seen from New Caledonia. A striking difference not recorded by Oliver, since it was not suggested by Brongniart and Gris, either in description or figure, is seen in the old capsules. In *X. moorei* the style remains slender and becomes twisted like the long staminal filaments which, together with the shrivelled persistent tepals, form a thready tangle about the opened capsule.[2] In *X. callistemon* the style thickens and dries firm and straight and stiffly erect so that the raceme permanently retains its brush-like appearance (Fig. 4B, E, Fig. 5). In both species the spreading of the capsule valves at dehiscence tends to split the style base into its three constituent parts, with frequent breakage in *X. moorei.*

Brongniart and Gris (1868: 3) describe fertile seeds of *X. moorei* as 1.5 mm. long, "uno latere convexa, aculeis brevibus apice inflatis truncatisque exasperata, altero nudo lateraliter raphe carinato." This description and their accompanying figures agree rather well with seeds of *X. callistemon.* Seeds from the capsules recently received from New Caledonia (Fig. 4F) are regularly longer than those of *X. callistemon* and almost oblong in outline; processes cover the surface except on rather vaguely defined furrows at the sides of the prominent keel which is itself echinate along its ridge. In *X. callistemon* (Fig. 4C) the seeds taper somewhat towards one end, the keel is smooth and the inner faces are plane and sharply distinct from the outer curved face which alone is echinate with semitransparent blunt cylindrical processes; processes in *X. moorei* are equally blunt but darker, more opaque and more inclined to be bent.

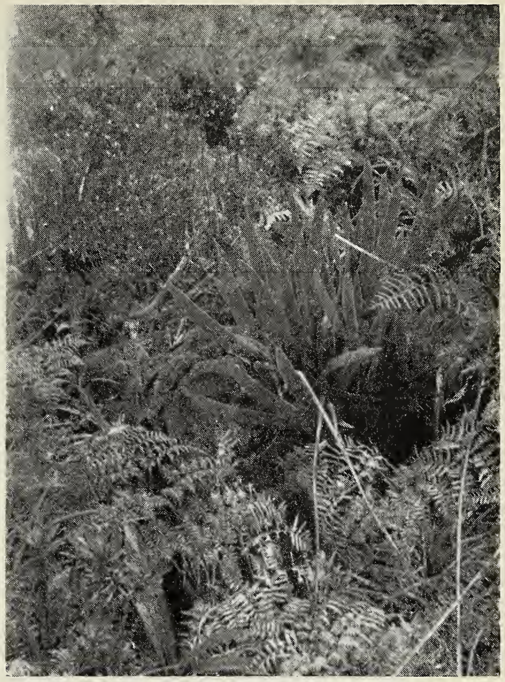


FIG. 2. *X. moorei.* Montagne des Sources, New Caledonia; on top of rocky ridge. 1955. Photograph by L. J. Dumbleton.

The pollen of *X. callistemon* has been described and figured (Cranwell, 1942: 293; 1953: 49, pl. 5, text fig. 38). That of *X. moorei* is slightly smaller but with similar exceedingly characteristic reticulation of the exine (Cranwell, 1953, from herbarium specimen, confirmed by N. T. Moar (personal communication) from fresh pollen).[3]

ECOLOGY AND DISTRIBUTION

The habitats of the two species are probably as nearly alike as their different latitudes can provide. *X. moorei* in New Caledonia (Lat. 22° S) "seems to do best on rather rocky narrow ridges more or less in the cloud belt" (Dumbleton, in litt.). Selling (in Guillaumin,

[2] "Les filets staminaux longs, secs et persistants du *Xeronema*, même a l'époque de la maturité du fruit, lui donnent un aspect tout particulier d'où nous avons tiré le nom générique" (Brongniart and Gris, 1868: 5). Compare the erroneous explanation in Cranwell and Moore, 1938: 25 and Moore, 1953: 26.

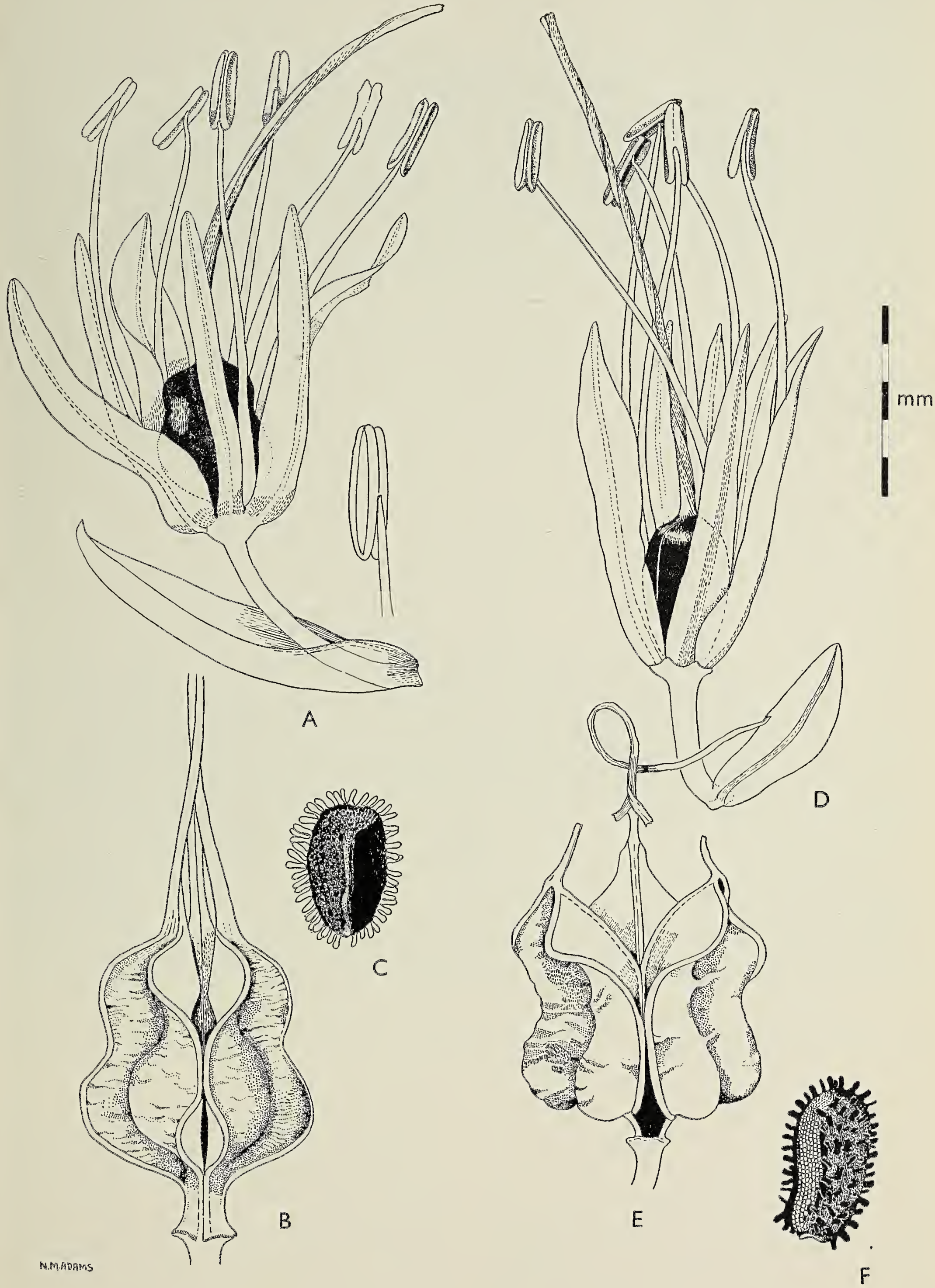
[3] Chromosome numbers of *Xeronema* have been counted by Dr. J. A. Rattenbury of Auckland University College. *X. moorei* from Montagne des Sources has a somatic number of 2n = 72 (unpublished) and *X. callistemon* from Hen Island a somatic number of 2n = 36 (*Roy. Soc. New Zeal. Trans.* (1957) 84 (4)). Specimens from which root tips preparations were made are growing at Auckland University College.

FIG. 3. *X. callistemon*. Hen Island, New Zealand; on cliff edge, sea in background. 1933. (*Arthropodium cirratum* in foreground.) Photograph by L. M. Cranwell.

1925: 13) records it from "Montagne des Sources, *Araucaria Muelleri*-forest, 800 m., not uncommon"; his photograph (*loc. cit.* Fig. 8) shows this as a rather open forest where much light reaches the rocky floor. K. H. Marshall (1954: 21) mentions, above the "clouds" forest, "a small natural clearing of about one square chain, at 5,000 feet, just crammed full of xeronema in full bloom."

On the New Zealand offshore islands good drainage and plenty of light seem essentail for *X. callistemon*, as on ledges and tops of cliffs to an altitude of 300 metres, and, on the northern island of the Poor Knights, on flat ground where rhyolitic soil is "very poor, dry and inhospitable" (Cranwell, 1937: 104, pl. 26). Seedlings are established only in well-lit places. On cliff faces plants that have accumulated great masses of leaf-debris not infrequently break off. Those that fall to the floor of rather dense forest do not long survive in the shade there. Some tumble into the sea and such a clump was found washed up on one of the Chickens Islands where the species is not known to grow (Cranwell and Moore, 1935: 309); it is quite unlikely that the sea could ever lift a whole plant to a place where it could establish afresh and so extend

FIG. 4. A–C: *X. callistemon*. A, flower from middle of raceme, garden-grown by Mrs. A. R. Pickmere (BD 50094A); B, capsule, garden-grown by Dr. W. R. B. Oliver; C, seed, Poor Knights Island, keel view: pale processes confined to outer rounded surface and seen only peripherally, keel and inner faces smooth. D–F: *X. moorei*. D, flower from middle of raceme, Mont Mou (BD 83585B); E, capsule, Montagne des Sources (BD 87634); F, seed, Montagne des Sources, lateral view showing dark processes on rounded outer surface to right and on keel to left. Scale applies to flowers and capsules; seeds drawn twice as large; enlarged anther shows filament inserted in pit between anther lobes. Drawings by Nancy M. Adams.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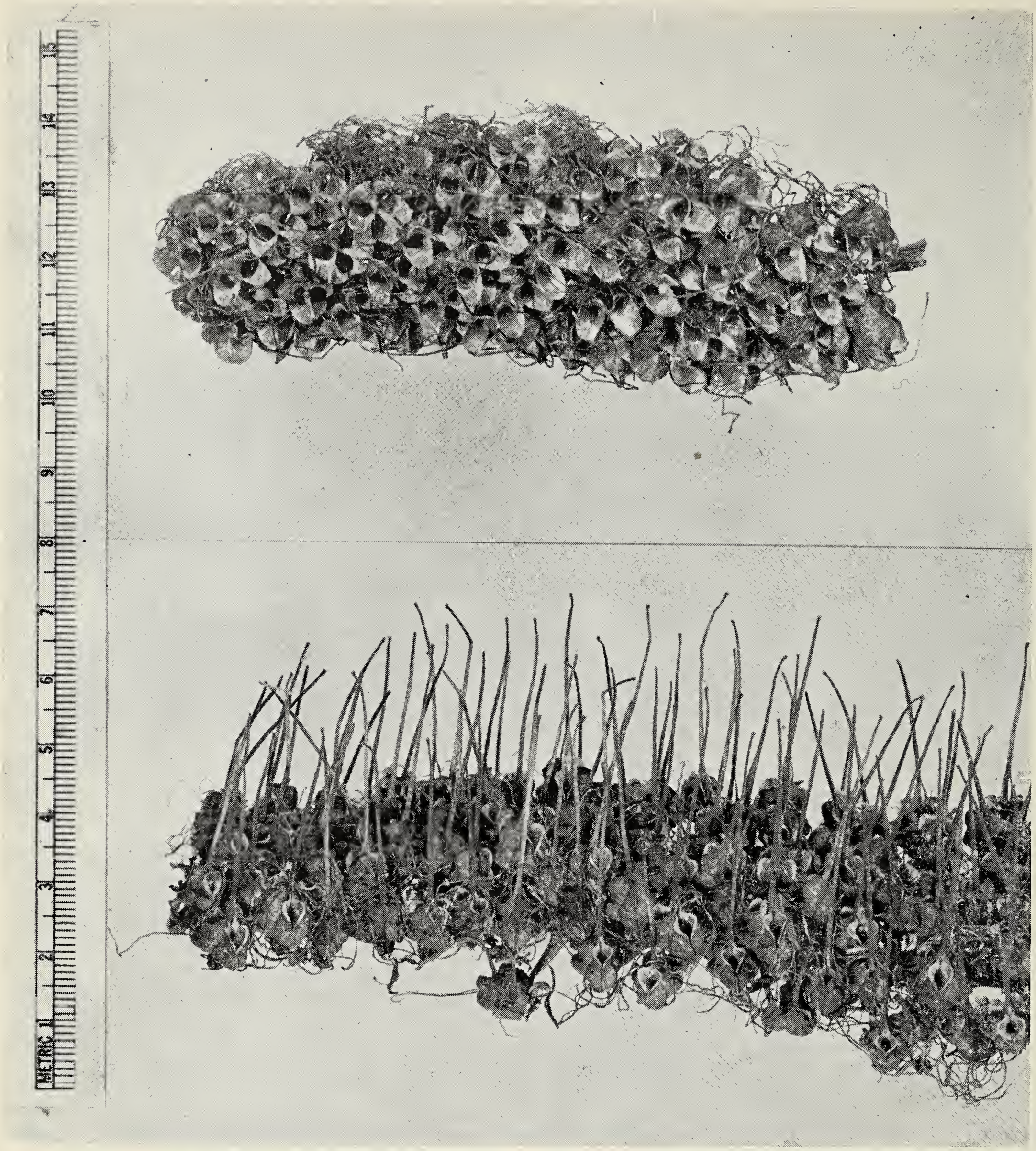

FIG. 5. Racemes with dehisced capsules. Above, *X. moorei*, Montagne des Sources, whole raceme, styles twisted and tangled with dry threadlike tepals and stamens; below, *X. callistemon*, garden-grown by Dr. Oliver, portion of raceme only, styles stiff and erect. Photograph by S. N. Beatus.

the range of the species.

Except that seeds drop easily into rock crevices at lower levels, neither species has an efficient dispersal mechanism. Of the numerous seeds in each capsule many fail to mature, some are shaken out, and some escape only when the capsule finally disintegrates.

X. moorei is known only from New Caledonia. *X. callistemon* has been found on two of the many island groups off the North Auckland coast, but not on islands between these two. The same sort of "spotty" distribution is shown by *Meryta sinclairii* (also

with affinities with New Caledonia) growing on Hen and Chickens and Three Kings Islands but not on Poor Knights and other intermediate groups. The recent discoveries on Three Kings of *Plectomirtha baylisiana* (Anacardiaceae) and *Tecomanthe speciosa* (Bignoniaceae) (Oliver, 1948: 224, 233), representing families not otherwise known in the New Zealand flora, and of the new genus *Elingamita* (Myrsinaceae) (Baylis, 1951: 99–102), illustrate also how important these offshore islands are from the point of view of plant geography. The cliff habitat of *X. callistemon* should save it from fire which is the worst menace to these significant but vulnerable vegetation remnants.

ADDITIONAL NOTES ON *X. callistemon*

Cockayne (1928: 73) places *X. callistemon* in the highest class from a horticultural standpoint. Although it is not yet listed by nurserymen it is grown in many gardens and has flowered as far south as Nelson. At the Royal Botanic Gardens, Kew, plants had been established by 1938 and the species flowered there for the first time in 1953. Garden plants have provided useful supplementary information about this rare species.

In Hatea Street, Whangarei (30 miles south of the Poor Knights Islands), at the home of the late Mrs. A. R. Pickmere, *X. callistemon* has been grown in pots and in open ground since 1924, flowering first in 1932, and the original plants are still thriving in 1956. These plants set good seed and some details of germination and growth rate have been recorded from them (Cranwell and Moore, 1938: 27). A seedling from the first flowering has bloomed at Te Aroha at the age of 22 years. Dr. W. R. B. Oliver has a plant in a sandy coastal garden at Seatoun, Wellington, North Island, brought from Poor Knights in 1933 by Cranwell and Moore; this has produced flowers regularly since 1942, with a maximum number of 16 inflorescences in 1951 and a total in nine recorded years of 48 flower heads. Seeds from this plant have been successfully germinated.

Miss E. K. Pickmere pointed out in 1942 (in litt.) that amongst plants from Poor Knights Islands two distinct forms can be recognized at flowering, and particularly at bud stage, though vegetatively all are alike. The difference lies in the floral bracts which in most of the plants under observation in the garden are definitely longer than the pedicel, exceeding the bud length, and are green at the time the flowers open (Fig. 4A, of BD 50094A[4]); in other plants, as in Dr. Oliver's (and in *X. moorei*), the bracts are barely as long as the pedicels and are red and scarious from the beginning (e.g., BD 50094B). In two plants, both from the southern island of Poor Knights and growing in one pot, bracts were measured in 1943; larger bracts on basal, middle and upper flowers were 4.5, 1.5, and 0.7 cm. long while smaller ones were 1.3, 1, and 0.5 cm. long respectively. The difference has been maintained in these garden plants over many years and in the one case where flowers of a seedling have been compared with those of its parent both are short-bracted. Two published colour pictures of this species suggest the difference though neither does the plant full justice. In a painting of a partly opened inflorescence (Laing and Blackwell, 1940, unnumbered) the longer green bracts are perhaps overemphasized; a colour photograph (N. Z. Gardener, 1954, Colour Supplement) shows a raceme at the stage where bracts begin to wither, but this appears to be of the short-bracted kind.

Garden plants have also provided material for an anatomical study (Mueller, 1928) of root, stem, and leaf. The cytological and embryological work required to make a detailed comparison between this genus and others in the subfamily Asphodeloideae (Cave, 1953: 142) awaits attention.

SUMMARY

Fresh material of *X. moorei* Brong. et Gris

[4] Number in the Herbarium of the Botany Division, D.S.I.R., New Zealand.

from New Caledonia has been compared with *X. callistemon* W. R. B. Oliver of New Zealand. Differences in perianth members and in form of fruit mentioned by Oliver are confirmed, but the sinus on the inner edge of the leaf is well-developed in both species and is not a distinguishing character. Hitherto-unmentioned differences are that the style at fruiting stage is thin and irregularly twisted in *X. moorei*, stout and stiffly erect in *X. callistemon;* in seeds of *X. moorei* the keel is echinate, in *X. callistemon* keel and well-defined inner faces are without processes. The montane habitat of *X. moorei* in New Caledonia is probably similar in some respects to the coastal cliffs of New Zealand offshore islands where *X. callistemon* grows. No morphological feature of either species suggests an explanation for the peculiar distribution of the genus, and of the New Zealand species. Garden plants provide supplementary information about *X. callistemon*, and in particular indicate that two forms may be differentiated on characters of the floral bracts.

REFERENCES

ANON. 1952. Colour Supplement. *New Zealand Gardener* 11(1). Sept. 1.

BAYLIS, G. T. S. 1951. *Elingamita* (Myrsinaceae). A new monotypic genus from West Island, Three Kings. *Rec. Auckland* (*N. Z.*) *Inst. and Mus.* 4(2): 99–102, 6 figs., 1 pl.

BENTHAM, G. 1862. Notes on Malvaceae and Sterculiaceae. *Linn. Soc. London, Jour., Bot.* 6: 97–123.

BRONGNIART, A., and A. GRIS. 1864*a*. Sur un nouveau genre de Liliacées *Scleronema. Ann. des Sci. Nat., Bot.* Sér. 5,2: 166–168.

——— 1864*b*. Sur un nouveau genre de Liliacées. *Xeronema. Soc. Bot. de France, Bul.* 11: 316–318.

——— 1868. Description de quelques Plantes remarquables de la Nouvelle-Calédonie. *Paris Mus. d'Hist. Nat., Nouvelle Arch.* 4: 1–48.

CAVE, M. S. 1953. Cytology and embryology in the delimitation of genera. *Chron. Bot.* 14(3): 140–153.

COCKAYNE, L. 1928. *Vegetation of New Zealand.* Ed. 2. xxiv + 456 pp., 87 pls., 3 maps. Engelmann, Leipzig.

CRANWELL, L. M. 1933. A new locality for *Xeronema callistemon. New Zeal. Jour. Sci. and Technol.* 15(3): 234–236.

——— 1937. New plant records from the Poor Knights Islands. *Rec. Auckland* (*N. Z.*) *Inst. and Mus.* 2(2): 101–110.

——— 1942. New Zealand pollen studies I. *Rec. Auckland* (*N.Z.*) *Inst. and Mus.* 2(6): 280–308.

——— 1953. New Zealand pollen studies. The monocotyledons. *Bul. Auckland* (*N. Z.*) *Inst. and Mus.* 3: 1–91, 8 pls.

CRANWELL, L. M., and L. B. MOORE. 1935. Botanical notes on the Hen and Chickens Islands. *Rec. Auckland* (*N.Z.*) *Inst. and Mus.* 1(6): 301–318.

——— 1938. *Xeronema:* an island lily. *New Zeal. Inst. Hort. Jour.* 8(1): 25–27.

GUILLAUMIN, A. 1952. New Caledonian plants. *Acta Horti Gotoburgensis* 19(1): 1–29, 4 pls.

LAING, R. M., and E. W. BLACKWELL. 1940. *Plants of New Zealand.* Ed. 4. xvii + 499 pp. Whitcombe and Tombs, Christchurch.

MARSHALL, K. H. 1954. Plants and vegetation of New Caledonia. *Wellington Bot. Soc. Bul.* 27: 19–21.

MOORE, L. B. 1953. Coastal plants. *Post-primary School Bul.* 7(7): 1–32.

MUELLER, J. 1928. *Xeronema callistemon.* Thesis (unpub.) deposited at Auckland Univ. Coll.

OLIVER, W. R. B. 1925. Vegetation of Poor Knights Islands. *New Zeal. Jour. Sci. and Technol.* 7: 376–384.

——— 1926. New Zealand angiosperms. *New Zeal. Inst. Trans.* 56: 1–5.

——— 1948. The flora of the Three Kings Islands. *Rec. Auckland* (*N.Z.*) *Inst. and Mus.* 3(4, 5): 211–238.

Impact Scars at Kilauea[1]

Chester K. Wentworth[2]

Kilauea caldera is an ellipsoidal area about two by three miles in extent, whose floor around its eastern, northern, and northwestern margins stands 200 to 500 feet below the surrounding surface of Kilauea volcano. At the southwest the caldera is open at grade and any copious lava flow would pass out and down the south slope of the volcano. The floor of the caldera is a low basaltic shield which at its apex, around Halemaumau, stands more than 200 feet above the lower parts of the northeast margin.

Halemaumau, the so-called firepit, is at present somewhat more than 3,000 feet in diameter, and its floor, at about 450 feet below the rim, consists of the surface of the 1954 lava flow, with a few protruding cone remnants from the more bulky 1952 flow. The floor of the caldera to the north, east, and northeast of Halemaumau consists of pahoehoe lava flows marked by tumuli and other characteristic features. Parts of the area to the west and south show the fresh surface of the 1921 lava flow, but more of the area to the south and west is mantled by ash beds and by thin layers and surface windrows of pumice. Surrounding Halemaumau, which was enlarged greatly by phreatic explosions in 1924, the surface of the caldera floor is strewn with blocks thrown out at that time and ranging up to several feet in diameter. On the eastern side, where the blocks landed on bare lava flows, in many instances the blocks broke through the surface lava layers into blister or other cavities beneath. Some remained in the holes and others ricocheted beyond, commonly showing their origin from the direction of the firepit. On the western side, the ash layers were thicker and offered more cushioning; here there are a few impact craters where blocks fell, but these are not as conspicuous as those of another older series which are to be described in this paper. The limits to which blocks of the 1924 explosive eruption were thrown are easily seen in the field. The holes in the lava are shown in Figure 1.

The caldera margin, from the east side around to the north and west and to the southwest of Halemaumau, is a rock cliff in which the lava flow section is clearly exposed. The southeast and south margin falls in an area where ash layers from successive eruptions amount to 30 or more feet in thickness. Along this line the surface faulting is compound and the ash section shows several parallel cracks with displacement along some. The hard rock margin is exposed in only a few places. To the south and southwest, the margin of the caldera is outlined by a rolling, sand-covered surface, with lava rock a few feet down, but exposed only in gullies that notch the margin.

[1] Publication authorized by U. S. Geological Survey. Manuscript received July 2, 1956.

[2] Hawaii National Park, Hawaii.

FIG. 1. A hole in the crust of the pahoehoe formed by the block shown, flung from the pit of Halemaumau by phreatic explosion in 1924.

Southeastward from Halemaumau, after passing the area of the 1924 blocks and coming onto the ash terrane between the tourist parking field and Keanakakoi Crater, there is revealed an area marked by numerous circular scars. This area, outlined on Figure 2, is strewn with blocks, ranging to several feet in diameter. It extends across the several linear terraces and crack scars leading up to the smooth upland southwest of Keanakakoi Crater and several hundred feet beyond before the blocks and the circular scars come to an end. An area of the scars runs north of the road, toward the west being practically on the level filled by the Kilauea lavas, then they are found on the higher level to the east and continue to beyond Keanakakoi. The principal area is south of the road, running southward toward the principal rim bluff, here marked by ash. The scars continue beyond the bluff however and are found on the upper sandy plateau to the southward (Fig. 2).

The gritty, block-strewn surface carries a scanty vegetation, consisting of a few small ohia trees (*Metrosideros polymorpha*) 6 or 8 feet high, scattered shrubs of pukeawe (*Styphelia Tameiameiae*), ohelo (*Vaccinium reticulatum*), and kupaoa (*Railliardia* sp.), a few small, isolated ferns, sedges, and grasses, a native *Portulaca* species, and kukae nene (*Coprosma ernodeoides*).

The impact scars are outlined by rings, generally 2 to 12 feet in diameter (Fig. 3). A few are as much as 20 feet across. The rings consist in part of coarser fragments ranging up to 6- or 8-inch blocks and are conspicuous because of the lag effect whereby associated finer material has been blown and washed away. Within each ring is a central depression a few inches to one or two feet deep, with a surface of finer silt which has washed in from the surrounding ring (Fig. 4). In many of the rings the silt of the central depression has a slightly cemented crust due to drying out of capillary moisture, in common with most of the surface of the ash terrane. The general appearance of the rings, where they are closely spaced, resembles polygonboden, but the similarity is certainly superficial and is due to lag processes rather than to frost (Fig. 5).

The larger rings often retain the blocks that apparently caused them, or the block responsible can often be identified with confidence a few feet beyond (Figs. 6 and 7). There is a preponderance of indicated flight directions stemming from the vicinity, roughly, of the present Halemaumau. Some of the blocks have broken on landing, as also have some of those of the 1924 series.

Many of the rings are marked by one or more small trees or shrubs which have taken

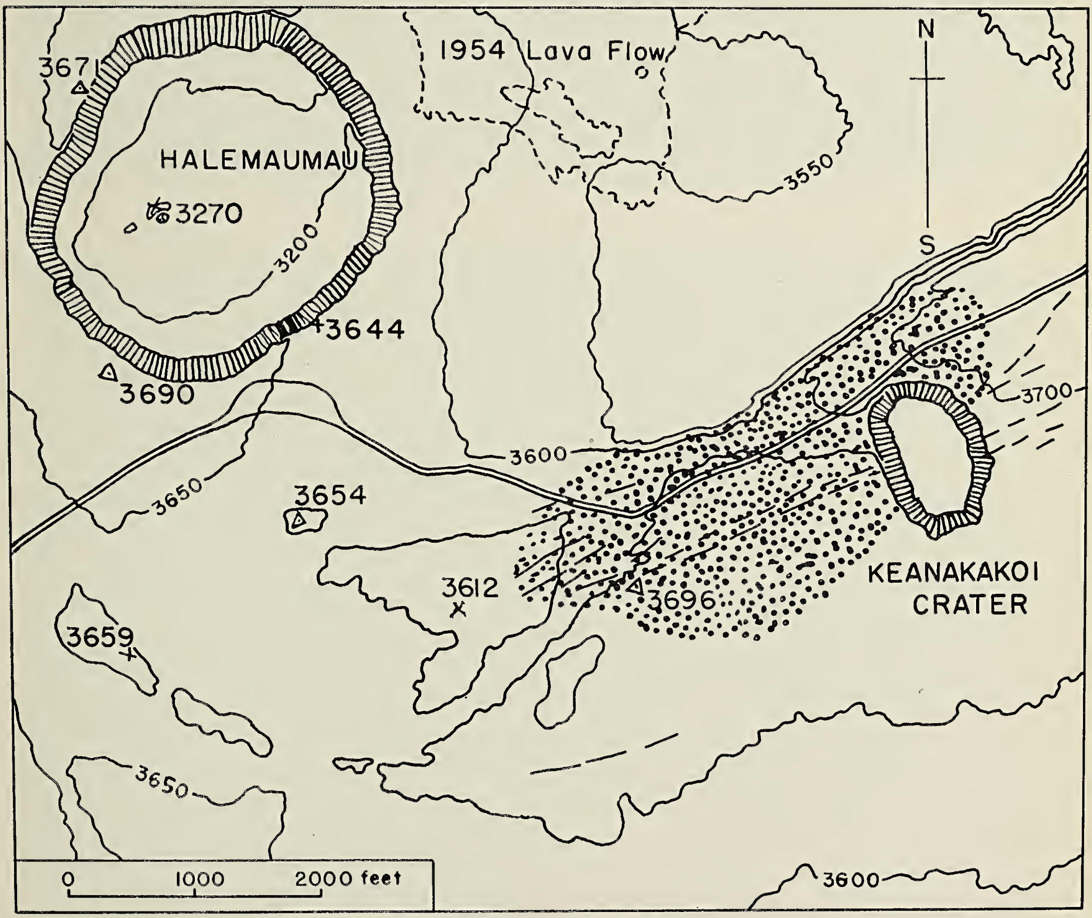

FIG. 2. Sketch map showing the southern part of the caldera of Kileauea and distribution (stippled area) of the impact scars here described.

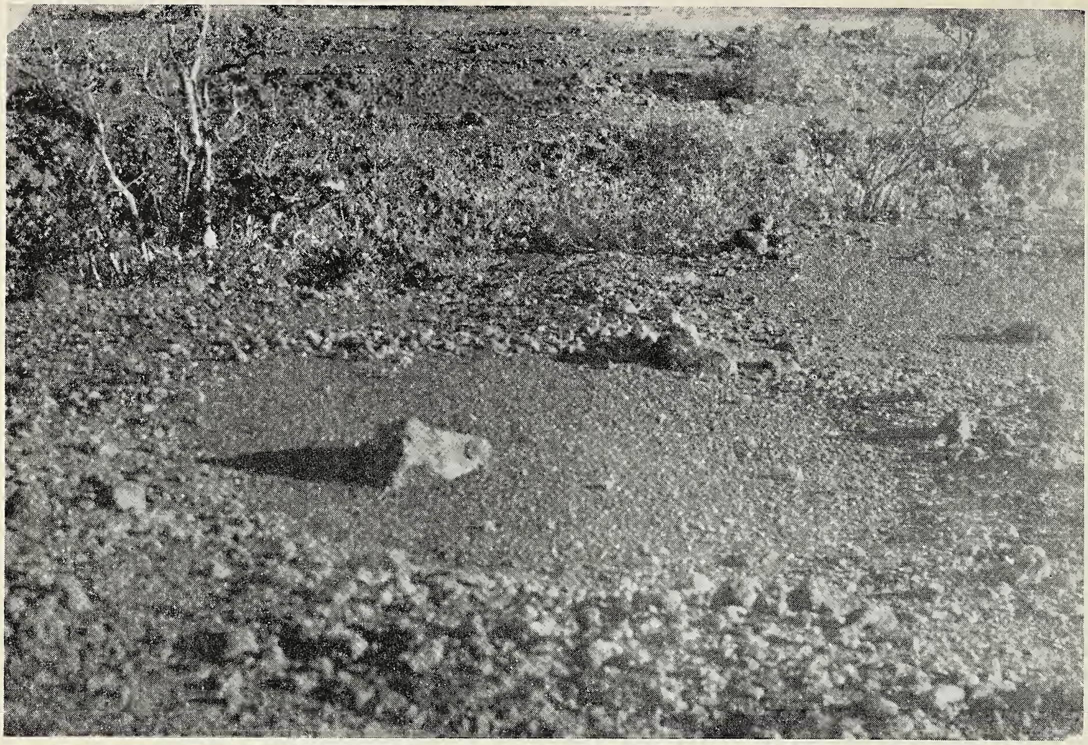

FIG. 3. Scar with small stone within. Scar about 7 feet across.

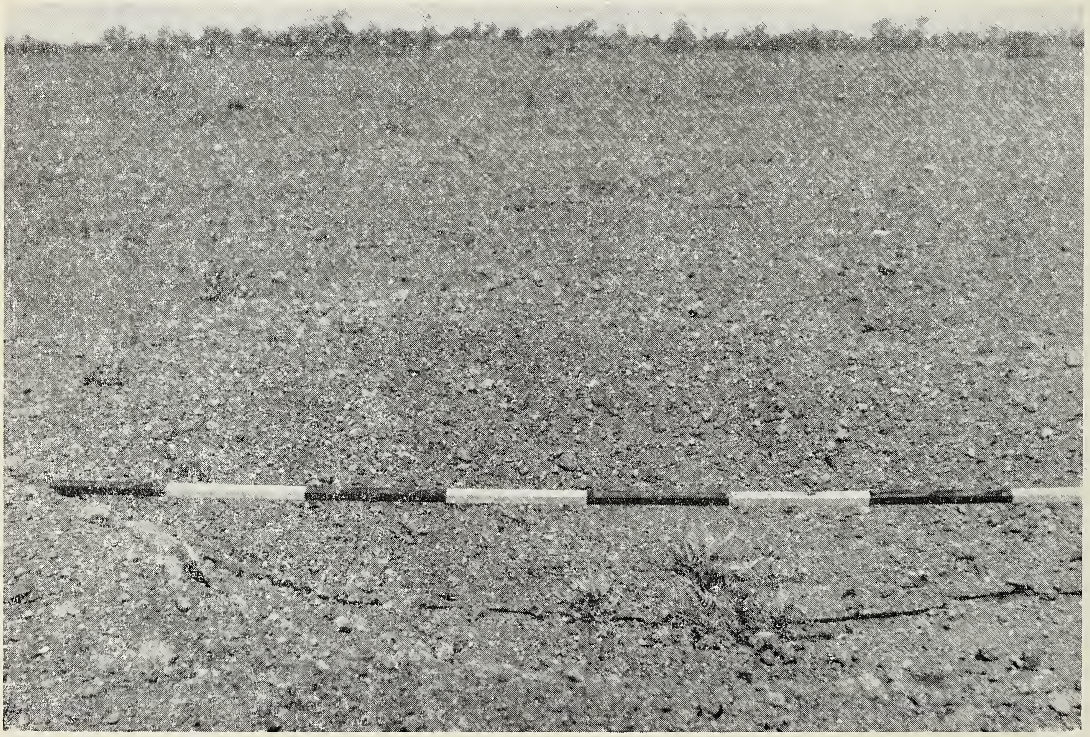

FIG. 4. Scar with pole laid across to show depth. (Pole is marked in one-foot divisions.)

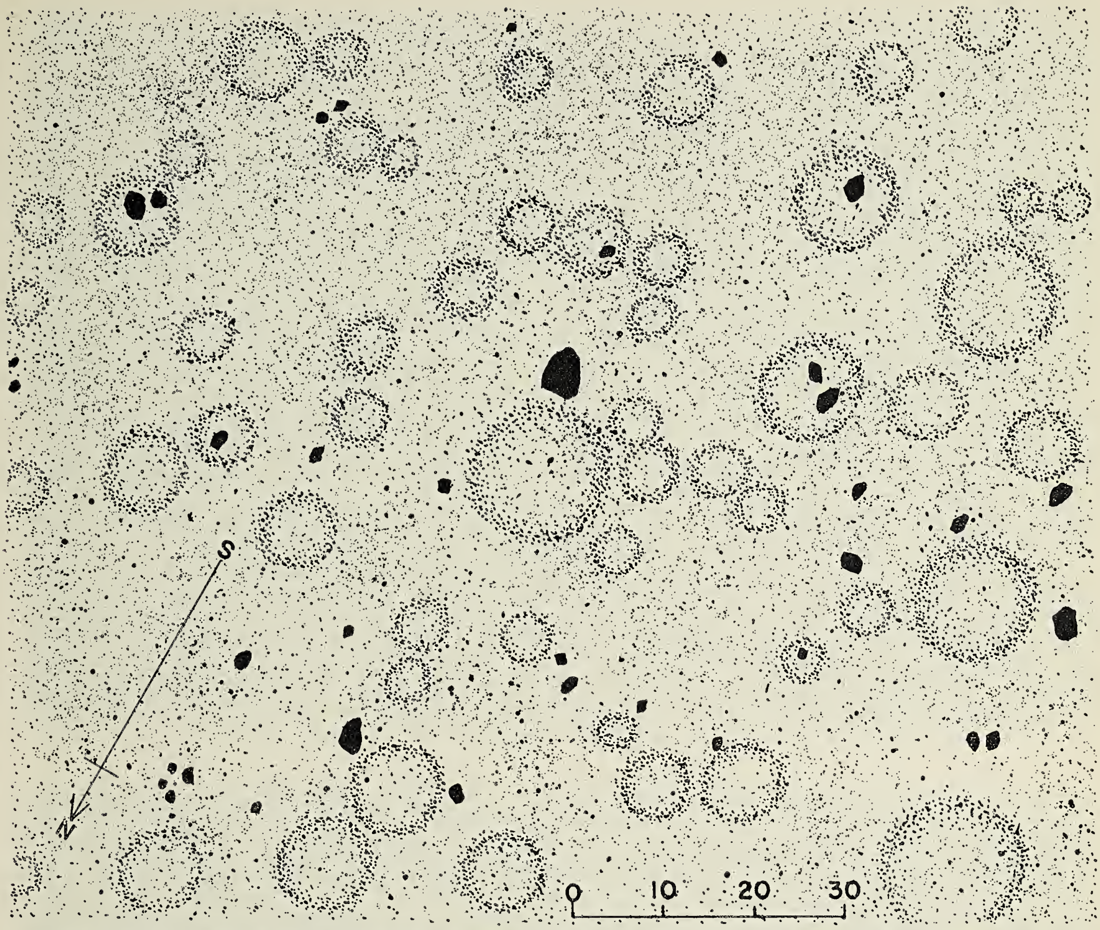

FIG. 5. Pattern of area where the scars are thickest, sketched by rope survey. The large black spots are by actual survey of size and position; smaller pattern of rings is by survey but dots are symbolic.

root in the finer soil of the center portion, or in the shelter of the block which remains. Other vegetation also is somewhat adapted to the ring pattern.

It can reasonably be supposed that this outer series of scars was formed in the 1790 eruption. If they had been formed earlier they would likely have been destroyed by the ash flung out by that eruption. However, there is no contemporary record and we are left with this very general evidence and presumption. That eruption was very violent and threw out much accidental material.

The rims are by no means covered by coarse blocks, and at midday the whole pattern is fairly faint, though discernible by a person who looks for it. At sunrise and in late afternoon the rings are most conspicuous from their relative relief. In the central part of their distribution the rings occur perhaps in every 20-foot square of the ground; around the margin of the area they are scarcer, perhaps two or three in an acre.

FIG. 6. Ring with pole showing depth and with responsible block beyond.

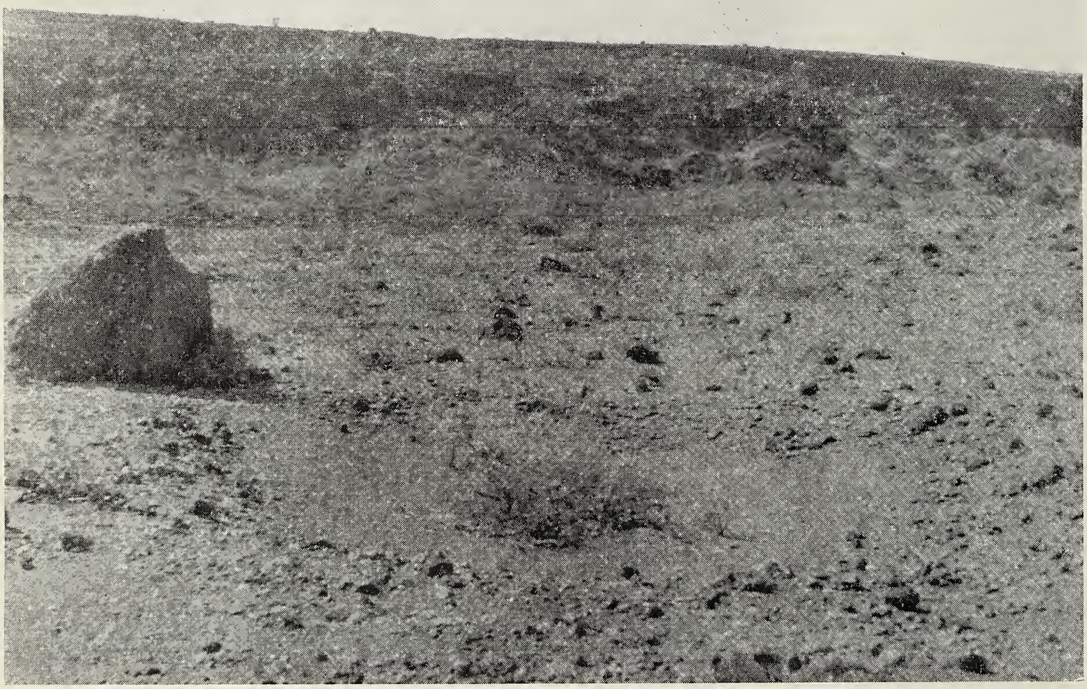

FIG. 7. Same as Figure 6, as seen from another direction.

FIG. 8. Several rings can be seen, that in the foreground having vegetation in it and broken stone at the left.

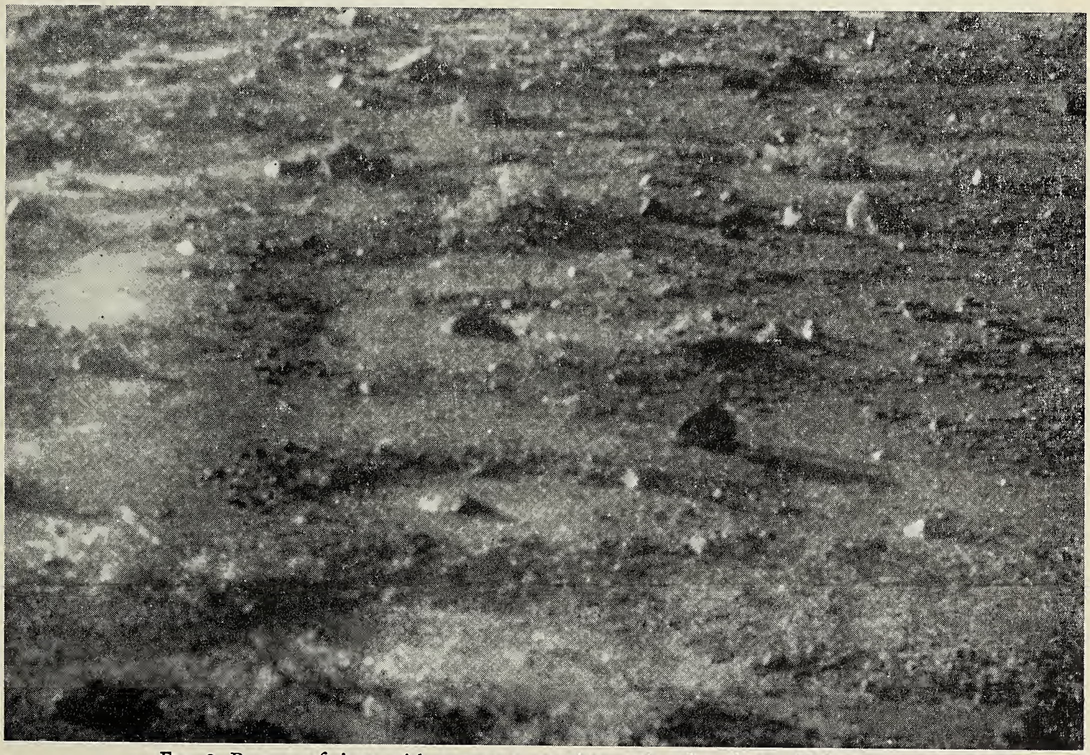

FIG. 9. Pattern of rings with stones on northern side of road near Halemaumau.

Notes on the Biology of the Wahoo in the Line Islands

Edwin S. Iversen[1] and Howard O. Yoshida[2]

Incidental catches of wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes), have been made by the Pacific Oceanic Fishery Investigations, a branch of the U. S. Fish and Wildlife Service, during experimental tuna fishing conducted from 1950 to 1956. The exploratory fishing, which extended from 180° to 130°W. longitude and from 10°N. to 13°S. latitude, has been carried out both close to the islands and in the open sea. The bulk of our wahoo data came from the Line Islands, which from south to north are: Starbuck, Malden, Jarvis, Christmas, Fanning, Washington, and Palmyra islands, and Kingman Reef. They extend in a general northwesterly direction from 5°S. latitude and 155°W. longitude to 7°N. latitude and 163°W. longitude. Although there is no organized fishery in the islands, the copra plantation workers (Gilbertese and Ellice islanders) use beach seines to capture a variety of lagoon and reef fishes and hand lines to catch an occasional tuna or wahoo.

Most of the published reports dealing with the wahoo are brief and are concerned primarily with its occurrence and distribution. The presence of wahoo was first noted in the Line Islands by Fowler (1938: 277). Rosa (1950: 75–77) lists a number of references which are of interest principally to taxonomists. In general the biology of the species is poorly known and has not been previously considered in the central Pacific.

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The wahoo, a member of the order Scombriformes, is a slender, streamlined fish with a sharp pointed head (Fig. 1). The mouth is large and is armed with razor-sharp teeth. Wahoo may weigh over 130 pounds and reach a length of nearly 7 feet. The body is steel-blue above and pale blue below. A series of bluish-black vertical bars, which fade soon after death, are present on the sides of the body. These fish are said to be very rapid swimmers and to make spectacular leaps out of the water.

The species is cosmopolitan in tropical and subtropical areas, and ranges at least as far north as Hawaii, where it is called "ono." Jenkins (1904: 441) examined wahoo in the Honolulu Market and reported that, "This is the first record of the species in Honolulu." In Hawaii today the species is of some slight importance as a sport fish. It is also sold commercially on the fresh fish market in Honolulu, but is of secondary importance. In 1953 the catch of 50,813 pounds during the year was sold for $11,166.94.

METHODS

The majority of fish available for this study were taken on standard surface trolling gear which is described by Bates (1950). This method of trolling employs about six lines attached to two long poles extending outboard, one from either side of the vessel. Trolling was mainly carried out from approximately 200 yards to 3 miles from the fringing reefs of the various islands. Some catches were also made on longline (flagline) gear, described by Niska (1954). Longline gear, which fishes well below the surface, was generally

FIG. 1. Wahoo captured by surface trolling in the Line Islands.

used in the open ocean, but some longline stations were occupied as close as 5 to 10 miles from land.

Length measurements were made in millimeters, using calipers. The fixed arm was placed on the tip of the upper jaw with the mouth closed, and the sliding arm of the caliper was placed at the fork of the caudal fin, being careful to depress the fleshy flap (Marr and Schaefer 1949: 242). Weights were taken in pounds, using a steelyard rigged to a davit on the deck of the vessel. Some difficulty was encountered in accurately weighing the fish when the vessel was under way, but most weights were taken when the vessel was in smooth waters or at anchor.

In preparing length-frequency distributions the lengths were first combined in 4-cm. groups and then smoothed by a moving average of three. Modal groups in these distributions are defined as the size classes with the highest frequencies in the smoothed distributions. Where several adjacent size classes are similar in height after smoothing, the center of these size classes is designated as the mode.

Stomach contents of the fish were recorded in the field as soon as possible after the fish were captured. The few parasites returned to the laboratory for examinations were preserved in 10 per cent formalin.

Measurements of ova for spawning and fecundity analysis were made with a dissecting microscope, employing a micrometer eyepiece measuring in units of 0.023 mm. The eggs were not perfectly symmetrical, so to avoid selection the "diameter" measured was the distance between two lines of the micrometer tangent to the eggs, the micrometer being held in one position during a series of measurements, following the method of Clark (1934: 7).

AVAILABILITY

Wahoo do not appear to form large compact schools. This simplifies the problem of

estimating their availability. Kishinouye (1923: 412) states that wahoo do not "make a school." Taylor (1951: 278), in discussing wahoo off North Carolina, reports that they do not form schools but that males and females group in pairs at spawning time. From our trolling catches close to shore it seems that this species tends to form small, loose, feeding aggregations, since we found that occasionally several wahoo would hit the lures simultaneously. Chapman (1946: 166) believes that they may form schools, for some of the wahoo he caught near Palmyra Island had frayed caudal fins, which he attributed to crowding in schools.

Some general knowledge of the vertical and horizontal distribution of wahoo is important when estimating the availability of this species. These aspects of the distribution can be roughly inferred from a comparison of longline catches and troll catches. The longline catches are small both close to land and in the open ocean. For example, Murphy and Shomura (1953*a*, 1953*b*, 1955) and Shomura and Murphy (1955) record only 59 wahoo captured on 14 POFI experimental longline fishing cruises involving numerous stations, some close to land. This figure suggests that wahoo are never abundant at the depths fished by this gear (200–600 ft.). Trolling operations were much more productive, but only close to land. Only 12 wahoo were caught during 5,500 hours of surface trolling in the open sea, more than 60 miles from land (Murphy and Ikehara 1955: 14). In contrast, within a few miles of land in both the Hawaiian Islands and Line Islands surface catches have averaged about 1 wahoo per hour (Table 1). From this information we infer that the wahoo prefer shallow depths and are more abundant close to land.

Even near islands wahoo are not very abundant in the central Pacific. This is suggested by the low catch rates from surface trolling around the Hawaiian and Line islands (Table 1). The troll catches obtained near the Line Islands during all seasons of the year indicate that the species does not occur there in sufficient numbers to support a profitable commercial fishery. This is also true in Hawaii (Welsh 1949*b:* 29). Neither does the wahoo appear to be very abundant in the Atlantic, at least off North Carolina, where Taylor (1951: 278) states that the population is small.

It is interesting to note from the Line Islands data (Table 1) that wahoo and yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel), have a similar pattern of seasonal variation in availability. This similarity could indicate that environmental or other factors

TABLE 1

RESULTS OF SURFACE TROLLING FOR WAHOO AND YELLOWFIN TUNA IN WATERS OF THE HAWAIIAN AND LINE ISLANDS

TIME	HOURS TROLLED	AVERAGE NUMBER OF LINES	WAHOO		YELLOWFIN	
			Number	Catch per hour	Number	Catch per hour
Hawaii						
Year around, 1947–48 (Welsh 1949b)	307	7.0	20	0.07	23	0.08
Line Islands						
April-June 1950 (Bates 1950)	285.5	6.1	178	0.62	882	3.09
March-April 1955	142.5	5.0	274	1.92	438	3.07
May-June 1955	116.0	6.0	135	1.16	100	0.86
July-August 1955	105.0	6.0	83	0.79	24	0.25
September-October 1955	182.0	6.0	245	1.35	171	0.94
November-December 1955	108.0	6.0	144	1.33	64	0.59
January-February 1956	133.5	6.0	267	2.00	148	1.10

influence both species similarly and are of greater importance than inter-specific competition for food, though both appear to feed on similar animals.

REPRODUCTION

In samples from the Line Islands, at all times of the year the percentage of males tends to be higher in the northern islands than in the southern islands (Fig. 2). This consistent trend or gradient suggests a migration of wahoo to maintain itself, unless there is varying differential mortality between sexes among areas, which seems unlikely. Such a gradient might be related to spawning movements but we are unable to describe them.

The wahoo in the Line Islands appear to spawn over an extended period of time, as is common with fish found in tropical waters.

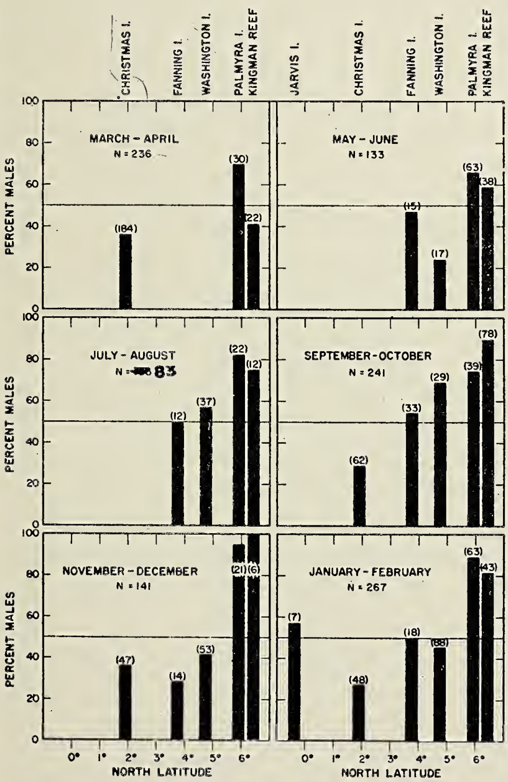

FIG. 2. Percentage of male wahoo by trolling areas, March 1955 to February 1956. (The number in each sample is shown in parentheses).

Cursory field examination of 80 females in March and of 143 in November and December, using categories devised by Marr (1948: 201),—i.e., immature, ripening, ripe, spawning, and spawned out—revealed all stages of maturity during both periods.

In order to estimate the number of eggs per spawning the size frequency distribution of ova in an apparently ripe ovary was determined for a fish of 131 cm. fork length (Fig. 3). Only eggs larger than 8 micrometer divisions, or 0.184 mm., were measured. An abundance of undeveloped or primitive eggs was present in the ovary, but most of these were not measured. The group 0.184–0.46

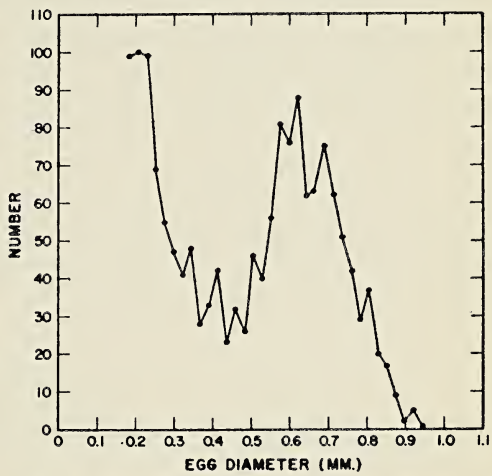

FIG. 3. Frequency distribution of egg diameters from a single female, 131 cm. fork length, captured May 1955 at Fanning Island.

mm. contained the larger of these "stockpile" eggs; the group from about 0.46 mm. to 0.94 mm., with a prominent mode at 0.62 mm. appeared to be maturing eggs. This latter group of eggs may be likened to the "type B" or developing eggs described by Tester and Takata (1953: 42) from the aholehole, *Kuhlia sandvicensis*. This one specimen showed no clear evidence of more than one mode among the developing eggs. The maturing group of eggs (> 0.46 mm.) in the ovaries of this female wahoo was estimated to number about 6.1 million. This estimate was obtained by weighing the formalin-preserved

(wet) ovaries, weighing a wedge-shaped section from one of the ovaries, and counting the number of eggs in the most mature group in this sample. The total number of mature eggs in both ovaries was then calculated by simple proportion.

This estimate of 6.1 million eggs per spawning is comparable in order of magnitude to the amount of spawn released by some other related species. Yuen (1955: 18) computed the number of eggs extruded in one spawning of a bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), in the Pacific to be 2.9 to 6.3 million; June (1953: 63) estimated the number of eggs per spawning of a yellowfin sampled in Hawaii to be 2 to 8 million. Both authors found that the number of eggs spawned increased, in general, with increase in size of fish. This probably holds true for the wahoo.

FOOD HABITS

Of the 235 stomachs examined, 115 (48.5 per cent) were empty. This relatively large number of empty stomachs may be due to regurgitation on capture. The wahoo struggles violently on the trolling line and may regurgitate food while being landed and killed. As some of the stomach contents were probably incomplete, an elaborate analysis of the food based on percentage by volume was not undertaken. Rather the analysis was confined to frequency of occurrence of the various food items.

Fish remains have a high frequency of occurrence among the food items (Table 2), and perhaps beyond their true significance since fish bones are slow to digest and hence persist longer in the stomachs than readily digested items. In both time periods (March, and November–December) mackerel scad, squid, and skipjack appear to be of importance in the food, with mackerel scad being the major item.

A much greater variety of food than is indicated by Table 2 is probably consumed by the wahoo. Very small items could have been overlooked. On infrequent occasions specimens were on deck for several hours prior to the examination of the stomachs, and the

TABLE 2
STOMACH CONTENTS OF 235 TROLL-CAUGHT WAHOO CAPTURED DURING MARCH, AND NOVEMBER-DECEMBER, 1955

FOOD ITEMS	FREQUENCY OF OCCURRENCE		PER CENT FREQUENCY OF OCCURRENCE	
	March	November-December	March	November-December
Items identifiable				
Squid (*Loligo* sp.)	6	3	18.2	13.0
Skipjack (*Katsuwonus pelamis*)	4	6	12.1	26.1
Pomfret (Bramidae)	1	1	3.0	4.4
Puffer (Tetraodontidae)	2	2	6.1	8.7
Mackerel scad (*Decapterus* [*psinnulatus*])	19	9	57.5	39.1
Flying fish (*Cypselurus* sp.)	1	..	3.0	...
Lantern fish (Myctophidae)	..	1	...	4.4
Sunfish (*Ranzania truncata*)	..	1	...	4.4
Total	33	23	99.9	100.1
Entire sample				
Empty stomachs	34	81	39.1	54.7
Fish remains not identifiable	20	44	22.9	29.7
Food remains identifiable	33	23	37.9	15.5
Total	87	148	99.9	99.9

identity of the more readily digestible forms could be lost during this time. Aside from these difficulties, it seems likely that the data in Table 2 provide a reasonably good picture of the food throughout the year. We do not believe there is much seasonal change in the fauna of the tropical Pacific.

The results of other studies suggest the diet of wahoo is similar throughout its range. Welsh (1949*a:* 22) made a preliminary examination of the food of wahoo in the Hawaiian Islands, using a rating system which considered total bulk of food, total number of food items, and the total number of times food was found in individual stomachs. Of the 17 stomachs he examined, 10 were empty. Those containing food held fish and squid. The food habits of the wahoo near Japan would seem to be nearly the same as in the Line Islands, for Kishinouye (1923: 412) states that they "feed on calamaries [squid] and pelagic fish."

LENGTH FREQUENCY ANALYSIS

An examination of the sizes of wahoo in our catches will contribute to our understanding of the biology of this species. In the Line Islands we sampled only a segment of the known size range of the species for small fish were not taken and much larger sizes have been recorded from other areas. Hosaka (1944: 69) reports a 124¾-pound wahoo taken on sport fishing gear off the island of Oahu, and LaMonte (1952: 9) reports a world record for wahoo as 133½ pounds (6 ft., 11 in.) caught in the Bahamas in 1943.

The size distribution of longline-caught wahoo is similar in most respects to that of fish taken on trolling gear. The longline catches, most of which are from the open sea, were made over several years at all months of the year and show a prominent mode at 128 cm. and a lesser mode at 146 cm. (Fig. 4). These fish range from 54 to 198 cm., with the majority between 106 and 162 cm. The measurements of troll-caught wahoo, taken mostly within 3 miles of land, during 1950,

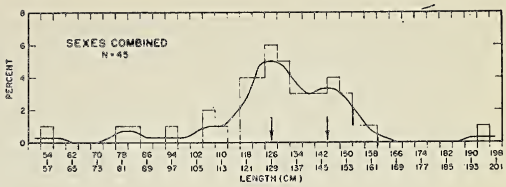

FIG. 4. Size frequency distribution of longline-caught wahoo, October 1950 to March 1955. (Smoothed by a moving average of three.)

1951, 1955, and 1956 show a similar size range, from 98 to 174 cm., and a similar distribution of sizes. It would appear then that both fishing methods sampled the same segments of a common population.

Samples of wahoo from some islands show differences in length distribution between sexes. An example of this in distributions of wahoo taken at Christmas Island during March and April 1955 (Fig. 5) shows a slight displacement of modes. In the male distribution there is a small mode at approximately 114 cm. and a dominant mode at approximately 134 cm.; in the female distribution there is a dominant mode at about 128 cm.

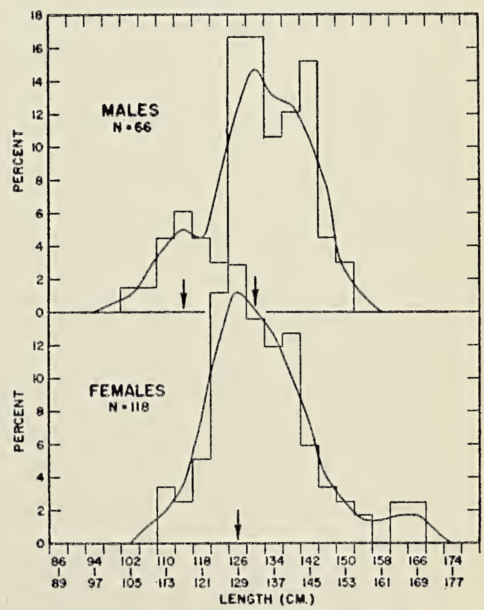

FIG. 5. Size frequency distribution of troll-caught wahoo from Christmas Island during March-April 1955. (Smoothed by a moving average of three.)

and a suggestion of a mode at approximately 164 cm. This suggests a differential growth rate between the sexes.

Wahoo show size variation associated with changes in latitude, as has been described for other scombrid fish. For example, Nakamura (1952: 101) found that the average weight of yellowfin tuna increased with latitude both to the north and south of the equator between the west coast of Sumatra and the Nicobar Islands. With respect to wahoo, the relative abundance of the larger fish appears to decrease from Christmas Island in the south to Palmyra Island and Kingman Reef in the north. This is accompanied by an increase in the numbers of smaller fish from south to north, these trends appearing in both the male and female length distributions (Fig. 6). The indications are that the wahoo are not distributed over the area in random fashion with respect to either size (Fig. 6) or sex (Fig. 2). Unless each area has a separate population with a different growth rate and sex ratio, there must be differential movement of individuals or groups in order to maintain the observed size and sex gradients. This movement, however, need not necessarily be confined to the study area.

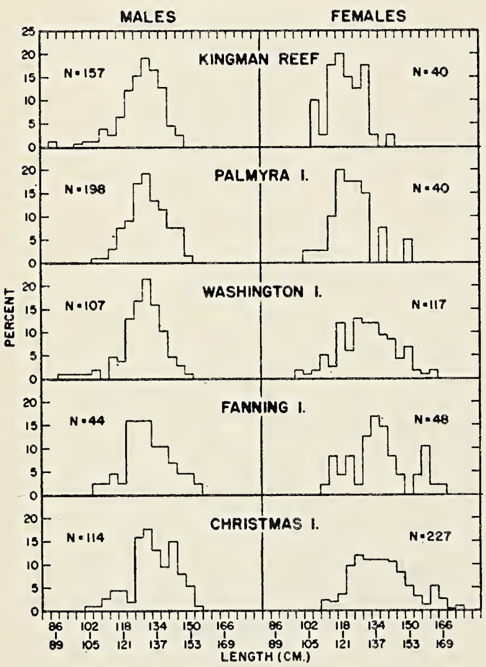

FIG. 6. Length frequency distributions of wahoo by areas, March 1955 through February 1956.

This nonrandom distribution of the wahoo makes it almost impossible to study growth by the method of progression of dominant modes in size frequencies because of the great difficulty in obtaining representative samples. Therefore such studies were not attempted.

LENGTH-WEIGHT RELATIONSHIP

As no significant difference in the length-weight relationship was noted between sexes, the data were combined to calculate the following regression equation which describes this relationship in the wahoo: Log weight $= -9.4199 + 3.50583$ log length, where weight is in pounds and length in millimeters. The mean weights for given lengths may be determined from the smooth curve shown in Figure 7. This large exponent, 3.50583, reflects the elongate, slender shape of the wahoo. As one would expect for a fish of this shape, a small increase in weight yields a relatively large increase in length. On the other hand

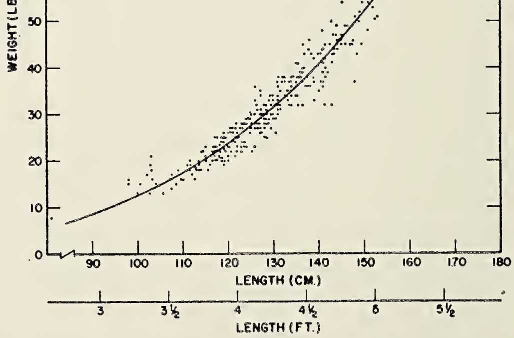

FIG. 7. Length-weight relationship for wahoo from the Line Islands, February 1951 to June 1955. Regression curve fitted by the equation: Log weight $= -9.4199 + 3.50583$ log length.

stout-bodied fish, such as some of the tuna, have a considerably smaller exponent. Examples are: yellowfin from Costa Rica, which have an exponent of 2.940 (Schaefer 1948: 119); and bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), sampled in Hawaii, which have an exponent of 2.9304 (Iversen 1955: 2).

PARASITES

Although no diligent search was made for parasites, the list given in Table 3 indicates that the wahoo is rather heavily parasitized. In the course of the examination of food items, trematodes about one inch in length when partially contracted were regularly noted at the posterior end of the stomach. Nigrelli and Stunkard (1947: 188) have carefully examined the genus *Hirudinella* and, on the basis of 33 specimens taken from wahoo captured in both the Atlantic and Pacific oceans, regard all forms of this giant trematode in the wahoo as belonging to a single species, *H. ventricosa* (Pallas).

In the 220 stomachs examined during March and November–December 1955 the number of giant trematodes per stomach ranged from 0–17 (Table 4). In all except the largest fish, two trematodes per fish were most commonly encountered, suggesting that this number represents a physiological equilibrium between host and parasite. On the other hand in the largest length group (160–179.9 cm.), four trematodes per stomach were commonly found.

SUMMARY

1. The availability of wahoo caught by trolling and longline fishing indicated the existence in the Line Islands of a small population that was most abundant in shallow water within a few miles of land.
2. Males were relatively more abundant in catches from the more northerly islands than in those from the more southerly islands.
3. Examination of wahoo gonads showed all

TABLE 3
Parasites of wahoo from the Line Islands, 1955

PARASITE	SITE OF INFECTION	NUMBERS PRESENT PER WAHOO	RATE OF INFESTATION	
			Per cent	Number of wahoo examined
Trematoda				
Neothoracocotyle acanthocybii (Meserve)[1]	Between gill filaments	Numerous	(high)	...
Didymocystis acanthocybii Yamaguti[1]	Head inside gill covers	Numerous cysts—2 worms/cyst	51.0	104
Hirudinella ventricosa (Pallas)	Caudal end of the stomach	0–17	98.2	220
Nematoda	Mass of worms embedded in belly wall	Many	(slight)	...
Copepoda				
Brachiella sp.	Within joint of pectoral fins	2 in each joint	98.3	118
Gloiopotes sp.	Outside surface of body and caudal fins	Many—variable	54.2	96
Pennella sp.	Embedded in belly wall with hind portion protruding	1 or 2	9.8	92

[1]Trematodes kindly identified by Dr. H. W. Manter, University of Nebraska, Lincoln.

TABLE 4
NUMBER OF GIANT TREMATODES IN STOMACHS OF WAHOO, BY HOST SIZE

NUMBER OF WORMS PRESENT	FREQUENCY OF OCCURRENCE BY HOST SIZE (CM.)							
	100–119.9		120–139.9		140–159.9		160–179.9	
	No.	%	No.	%	No.	%	No.	%
0	..	...	3	2.4	1	1.4	..	...
1	..	...	7	5.7	7	9.7	1	7.7
2	10	90.9	90	72.6	41	56.9	3	23.1
3	..	...	19	15.3	12	16.7	1	7.7
4	1	9.1	3	2.4	8	11.1	6	46.2
5	..	...	1	0.8	1	1.4	1	7.7
6	..	...	1	0.8	..	...	1	7.7
8	..	...	..	...	1	1.4	..	...
17	..	...	..	...	1	1.4	..	...
Total	11	100.0	124	100.0	72	100.0	13	100.1

stages of maturity present. The number of mature eggs in a single female was estimated at over six million.

4. The wahoo taken close to the islands showed little variety in their diet as judged by stomach contents. Of the identifiable food material the main items were mackerel scad, skipjack, and squid.
5. An examination of size frequency distributions from the Line Islands area revealed that the females attain a larger size than the males, and there is some suggestion that the two sexes grow at different rates. No attempt to estimate growth by modal progression is made since there are indications that the samples were not representative of a homogeneous population unit.
6. A length-weight relationship for wahoo from the Line Islands is given by the equation:

   Log weight (pounds) = $-9.4199 +$ 3.50583 log length (millimeters).
7. The wahoo was found to be parasitized by trematodes, nematodes, and copepods.

REFERENCES

BATES, D. H., JR. 1950. Tuna trolling in the Line Islands in the late spring of 1950. *U. S. Fish and Wildlife Serv., Fisher. Leaflet* 351: 1–32.

CHAPMAN, W. M. 1946. Observations on tuna-like fishes in the tropical Pacific. *Calif. Fish and Game* 32(4): 165–170.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*), determined by ova diameter measurements. *Calif. Dept. Fish and Game*, *Fish Bul.* 42: 1–49.

FOWLER, H. W. 1938. The fishes of the George Vanderbilt South Pacific Expedition, 1937. *Acad. Nat. Sci. Phila., Monog.* 2: 1–349.

HOSAKA, E. Y. 1944. *Sport Fishing in Hawaii.* ix + 198 pp. Bond's, Honolulu.

IVERSEN, E. S. 1955. Size frequencies and growth of central and western Pacific bigeye tuna. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 162: 1–40.

JENKINS, O. P. 1904. Report on collections of fishes made in the Hawaiian Islands with descriptions of new species. *U. S. Fish Comn., Bul. (1902)* 22: 417–511.

JUNE, F. C. 1953. Spawning of yellowfin tuna in Hawaiian waters. *U. S. Fish and Wildlife Serv., Fisher. Bul.* 54(77): 47–64.

KISHINOUYE, K. 1923. Contributions to the comparative study of the so-called Scombroid fishes. *Tokyo Imp. Univ., Col. Agr. Jour.* 8(3): 293–475.

LAMONTE, F. 1952. *Marine Game Fishes of the World.* 190 pp. Doubleday and Co., Inc., Garden City, N. Y.

Marr, J. C. 1948. Observations on the spawning of oceanic skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Neothunnus macropterus*) in the northern Marshall Islands. *U. S. Fish and Wildlife Serv., Fisher. Bul.* 51(44): 201–206.

Marr, J. C., and M. B. Schaefer. 1949. Definitions of body dimensions used in describing tunas. *U. S. Fish and Wildlife Serv., Fisher. Bul.* 51(47): 241–244.

Murphy, G. I., and I. I. Ikehara. 1955. A summary of sightings of fish schools and bird flocks and of trolling in the central Pacific. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 154: 1–19.

Murphy, G. I., and R. S. Shomura. 1953*a*. Longline fishing for deep-swimming tunas in the central Pacific, 1950–1951. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 98: 1–47.

——— and ——— 1953*b*. Longline fishing for deep-swimming tunas in the central Pacific, January–June 1952. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 108: 1–32.

——— and ——— 1955. Longline fishing for deep-swimming tunas in the central Pacific, August–November 1952. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 137: 1–42.

Nakamura, H. 1952. The tunas and their fisheries. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 82: 1–115.

Nigrelli, R. F., and H. W. Stunkard. 1947. Studies on the genus *Hirudinella*, giant trematodes of scombriform fishes. *Zoologica* [*New York*] 31(13): 185–196.

Niska, E. L. 1953. Construction details of tuna longline gear used by the Pacific Oceanic Fishery Investigations. *U. S. Fish and Wildlife Serv., Comn. Fisher. Rev.* 15(6): 1–6.

Rosa, H., Jr. 1950. *Scientific and Common Names Applied to Tunas, Mackerels, and Spearfishes of the World, with Notes on Their Geographic Distribution.* United Nations, F.A.O. 235 pp. Washington, D. C.

Schaefer, M. B. 1948. Morphometric characteristics and relative growth of yellowfin tunas (*Neothunnus macropterus*) from Central America. *Pacific Sci.* 2(2): 114–120.

Shomura, R. S., and G. I. Murphy. 1955. Longline fishing for deep-swimming tunas in the central Pacific, 1953. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 157: 1–70.

Taylor, H. F. 1951. *Survey of Marine Fisheries of North Carolina.* xii + 555 pp. University of North Carolina Press, Chapel Hill, N. C.

Tester, A. L., and M. Takata. 1953. *Contribution to the Biology of the Aholehole, a Potential Baitfish.* Indus. Res. Advisory Council. 54 pp. Honolulu.

Welsh, J. P. 1949*a*. A preliminary study of food and feeding habits of Hawaiian kawakawa, mahimahi, ono, aku, and ahi. *Ter. Hawaii Div. Fish and Game, Fisheries Prog. Rpt. 1*, No. 2: 1–26. (IN *Division of Fish and Game, Special Bulletin* No. 2, 1950.)

——— 1949*b*. A trolling survey of Hawaiian waters. *Ter. Hawaii Div. Fish and Game, Fisheries Prog. Rpt. 1*, No. 4: 1–30. (IN *Division of Fish and Game, Special Bulletin* No. 2, 1950.)

Yuen, H. S. H. 1955. Maturity and fecundity of bigeye tuna in the Pacific. *U. S. Fish and Wildlife Serv., Spec. Sci. Rpt., Fisheries* 150: 1–30.

Further Evidences of Anomuran Non-pedunculate Spermatophores[1]

Donald C. Matthews[2]

Macruran non-pedunculate spermatophores were differentiated from anomuran pedunculate spermatophores by Calman (1909), but subsequent studies embracing both macrura of the Palinuridae, Scyllaridae, and Nephropsidae (Matthews, 1951, 1954*b*, 1954*c*) and the anomura of the Paguridae (Mouchet, 1931; Matthews, 1953, 1956), placed this differentiation in doubt. However, not until it was discovered that a macruran, *Parribacus antarcticus*, elaborated pedunculate spermatophores (Matthews, 1954*a*) and an anomuran, *Hippa pacifica*, elaborated non-pedunculate spermatophores (Matthews, 1956) was the dichotomy between these two tribes proven to be untenable.

This paper, which compares the development of *Aniculus maximus* spermatophores with that of certain other Paguridae, records still other instances in which anomuran non-pedunculate spermatophores are produced.

MATERIALS AND TECHNIQUES

Mature specimens of *Aniculus strigatus* Herbst (Edmondson, 1946: 264; Forest, 1952: 19, *Trizopagurus strigatus* (Herbst)), collected at Hanauma Bay, Oahu, T. H., during the year 1954, and of *A. maximus* (*vide* Edmondson, *opus cit.* p. 79), obtained from the Honolulu Aquarium during the year 1953, were used in this study.

The right testis and vas deferens of each specimen of *A. maximus* were fixed either in Bouin's or Zenker's fluid, dehydrated and cleared in dioxane, embedded in Tissuemat (54–56°C.), and serially sectioned at 10 microns. The mounted sections were stained either with Harris's alumhaematoxylin (counterstained with eosin) or with Mallory's Triple Stain.

The left vasa deferentia of both species were immersed for 10–30 minutes in an aqueous solution of toluidine blue (1–10,000), teased open in sea water, and their vitally stained spermatophores studied.

OBSERVATIONS

In cross sections throughout the testis of *A. maximus* immature sacculi containing primary spermatocytes, and more mature sacculi containing secondary spermatocytes and spermatids, are observed. These sacculi, by the renewed activity of their germinal epithelial cells, produce new primary spermatocytes which, as they fill the sacculi, force the metamorphosing spermatids into the minute collecting tubule. Thus by combined, rhythmical activities of numerous sacculi a continuous sperm mass slowly enters the proximal portion of the vas deferens where, molded in compliance with the circular lumen, it forms a rodlike sperm column.

Serial cross sections through this region of the vas deferens disclose that the shape of the lumen gradually changes from circular to elliptical, synchronously effecting corresponding changes in the shape of the sperm column.

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As the sperm column becomes elliptical, a secretion from the epithelial cells bounding the more pointed extremities of the elliptical lumen envelops the sperm column and forms the sperm column sheath.

Serial sections through somewhat more distal regions of the vas deferens disclose that the lumen gradually becomes pear-shaped. In longitudinal sections through this region (Fig. 1) the sheathed, sperm column appears as a series of partially closed arches (*c*), joined one to another by portions of the compressed, empty, sperm column sheath (*d*).

Longitudinal sections through slightly more distal regions of the vas deferens (Fig. 2) disclose that a secretion from the epithelial cells (*f*) bordering the narrow portion of the lumen forms the foot (*e*) and fills with precursory stalk material (*d*) the spaces between the closing arches.

Thus far, the histological and physiological phenomena of spermatophoric development in *A. maximus* parallel those of *Dardanus punctulatus* (Matthews, 1956) and *Dardanus asper* (Matthews, 1953: 260–262, figs. 7, 8, 9, 10, 11) in which truly pedunculate spermatophores are ultimately elaborated.

In *D. asper*, as in *A. maximus*, the living vasa deferentia exhibit spasmodic contractions which serve both to move the sperm mass and to mold it in compliance with the gradually changing internal die, i.e., first cylindrical, then elliptical, then pear-shaped. In *D. asper* also, a secretion from epithelial cells isolated at opposite ends of the elliptical lumen forms the sperm column sheath. And this sheathed sperm column, by muscular contractions of the wall of the vas deferens, forms partially closed arches, joined one to another by portions of the compressed, empty, sperm column sheath. In *D. asper*, too, a secretion from the epithelial cells bordering the narrow portion of the pear-shaped lumen forms the foot and fills with precursory stalk material the spaces between the closing arches.

From this stage of development on, the processes in the elaboration of pedunculate and non-pedunculate spermotophores diverge. This divergence results, for the most part, from subsequent activities of the epithelial cells bounding the lumen.

In *D. asper* (*op. cit.*, p. 263, figs. 12, 13), the epithelial cells at the narrow region of the pear-shaped lumen form a groove into which the precursor of the stalks is secreted. As the groove deepens, the stalk material lengthens both by the continued secretion of the epithelial cells and by the muscular contractions in the walls of the vas deferens. It is noteworthy that the lengthening of the stalks carries the ampullae of sperm "above" the foot and that the connecting sperm column sheaths between adjacent ampullae become extremely thin and finally obscure. Even in the short spermatophores of *Birgus latro* and *Coenobita rugosus* (Matthews, 1956) the stalks are lengthened sufficiently to carry the ampullae of sperm "above" the foot.

In *A. maximus* (Fig. 3) the epithelial cells (*f*) fail to form a deep groove into which the precursor of the stalks is secreted. Instead, this region of the lumen (*d*) widens and the secretion from the epithelial cells spreads out forming the broad foot (*e*). Noteworthy also is the sectioned portion of an arch (*c*), which here measures 112 microns high and 71 mi-

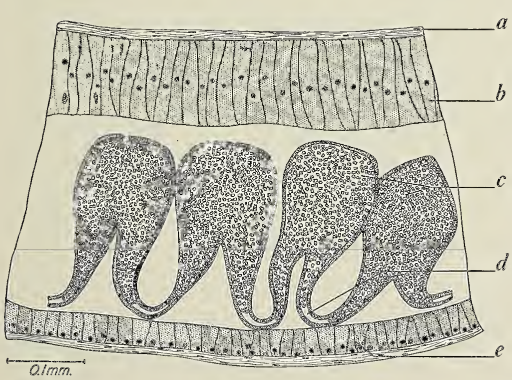

FIG. 1. Longitudinal section of the proximal vas deferens of *Aniculus maximus* showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, partially closed arches of sheathed, sperm column; *d*, compressed, empty sperm column sheath connecting partially closed arches; *e*, short, epithelial cells bounding narrow portion of lumen.

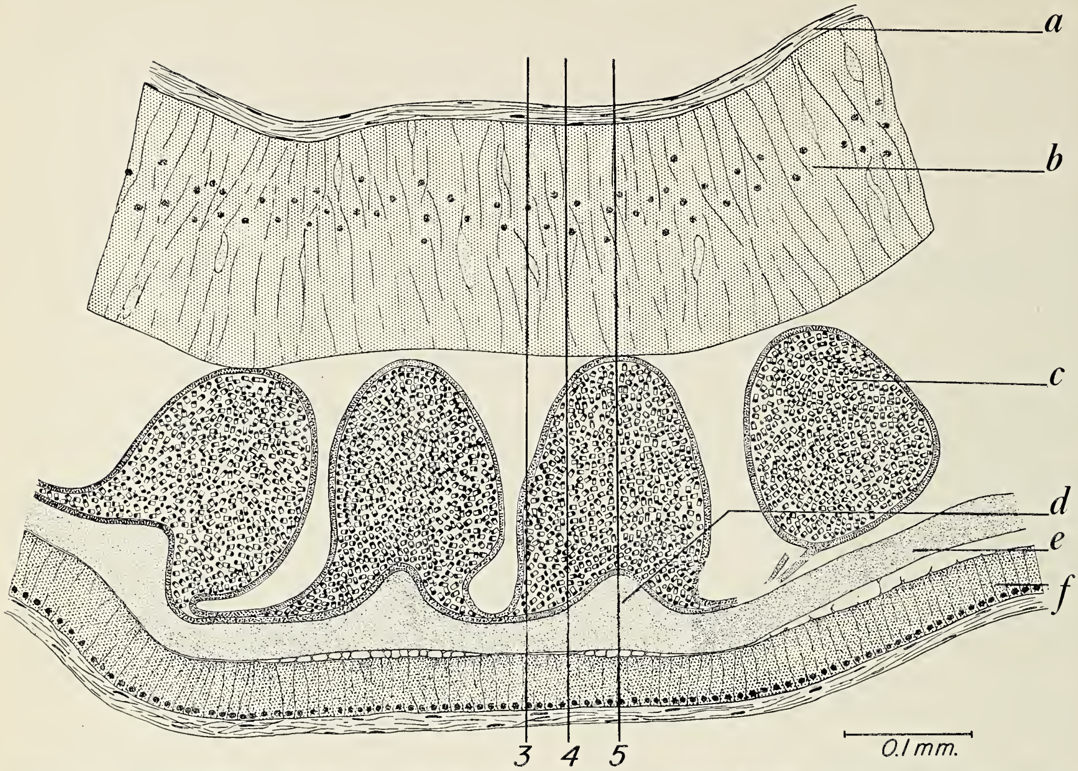

FIG. 2. Longitudinal section of the proximal vas deferens of *Aniculus maximus* (slightly distal to Fig. 1) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, precursory stalk material; *e*, foot; *f*, short epithelial cells of narrow portion of lumen secreting the foot material. (The numbers 3, 4, 5 show regions through which Figs. 3, 4, 5 are taken.)

crons wide and appears like a distinct ampulla resting on the broad foot (*e*).

In subsequent sections through this region of the vas deferens (Fig. 4) although the foot forming epithelial cells (*f*) do not shorten, the epithelial cells (*b*) "above" the sectioned portion of the arch (*c*) attain a length of approximately 182 microns. Again it is noteworthy that the sectioned portion of the arch (*c*) appears like a distinct ampulla 171 microns high and 118 microns wide. Whereas, in Figure 3 the "ampulla" appeared to rest firmly on the broad, basal foot, in Figure 4 it is "elevated" approximately 12 microns by the sectioned portion of the stalk precursor (*d*).

In still other cross sections through this region of the vas deferens (Fig. 5) neither the foot forming epithelial cells (*f*) nor the epithelial cells (*b*) above the sectioned portion of the arch (*c*) change appreciably in length. And again it is noteworthy that the sectioned portion of the arch (*c*) appears like a distinct ampulla, 171 microns high and 118 microns wide. The "ampulla" is elevated approximately 35 microns above the foot (*e*) by the sectioned portion of the stalk precursor (*d*).

The broad groove so characteristic of this portion of the lumen is no longer encountered in cross sections through the enlarged, apical portion of the vas deferens (Fig. 6). Gradually, the epithelium becomes folded and two typhlosole-like regions (*b*) appear at opposite sides of the lumen. From the epithelial cells bordering the crypts of these typhlosole-like folds, a new mucus-like secretion forms the matrix (*c*) which encompasses the completed spermatophores.

Because of its tortuous nature, both cross sections (*e*) and longitudinal sections (*d*) of

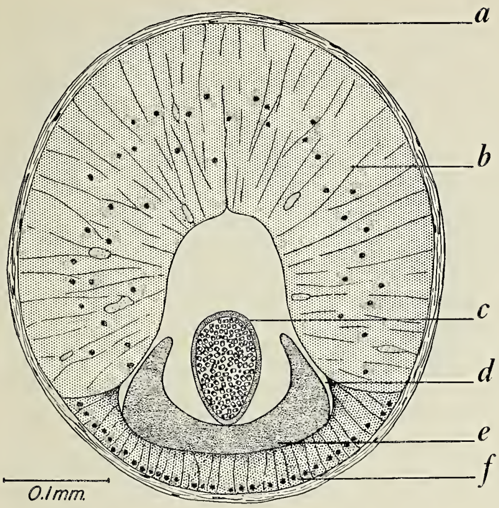

FIG. 3. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 3 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, portion of wide lumen; *e*, foot; *f*, foot-forming epithelial cells.

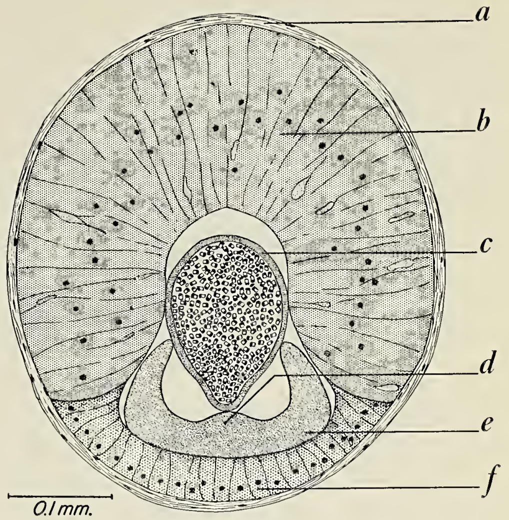

FIG. 4. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 4 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, stalk precursor; *e*, foot; *f*, foot-forming epithelial cells.

the spermatophore are here observed. Conspicuous also in these sections are the longitudinal muscles (*a*) which probably serve to eject the completed spermatophores (Fig. 7).

When the enlarged apical portions of the vasa deferentia of *A. strigatus* and *A. maximus* are placed in toluidine blue and their encompassing mucus-like matrices are dissolved (in 0.1N KOH), continuous, non-pedunculate spermatophores (Fig. 7) are revealed. Here is final evidence that the arches (*a*) never completely close forming distinct ampulla and that the arches are in reality never raised above the broad basal foot (*b*).

DISCUSSION

Mouchet (1931) assigns nine regions of activity to the vas deferens of the typical pedunculate spermatophore producing hermit crab, *Diogenespugilator* Roux (Matthews, 1953: 264). The spermatophoric differences observed in *A. strigatus* and *A. maximus* are attributed to vasa deferentia which lack one or more of these regions. We are especially concerned in this discussion with region 4, in which each ampulla acquires a short thick stalk, and with region 6, in which the stalks are stretched.

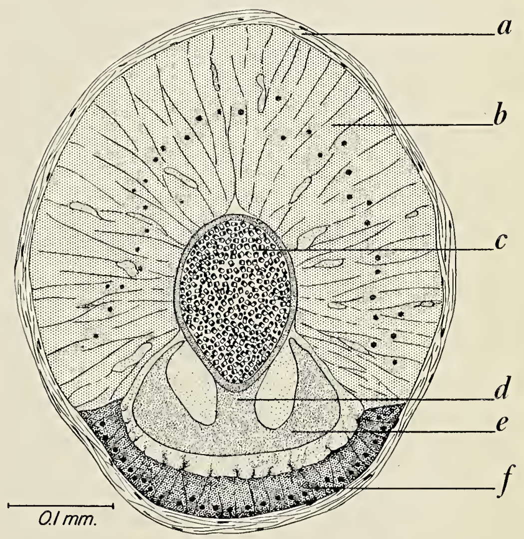

FIG. 5. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 5 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, stalk precursor; *e*, foot; *f*, foot-forming epithelial cells.

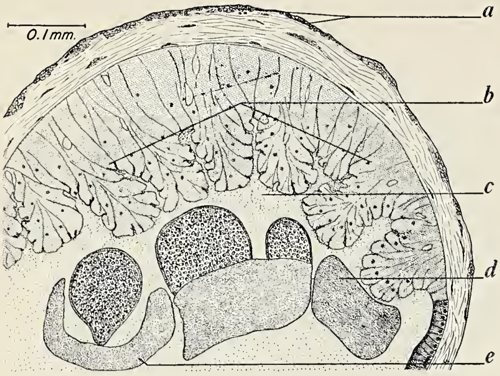

FIG. 6. Portion of cross section through enlarged distal vas deferens of *Aniculus maximus* showing: *a*, circular and longitudinal muscles; *b*, typhlosole-like region of epithelial cells; *c*, mucus-like matrix; *d*, longitudinal section through portion of spermatophore; *e*, cross section through portion of spermatophore.

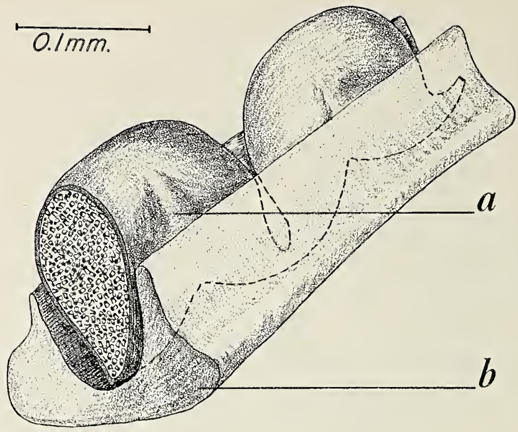

FIG. 7. A composite drawing of vitally stained extruded spermatophores of *Aniculus strigatus* or *Aniculus maximus* (with matrix dissolved away) showing: *a*, unclosed arch not elevated above foot; *b*, foot.

In my observation of the stained cross sections of *A. maximus* I am unable to determine with certainty whether region 4 is present or not. True, both cross and longitudinal sections reveal a "stalk precursor" which fills the spaces of the closing arches but this material, with the stains employed, could not, either in texture or staining affinity, be differentiated from that of foot. It is not the intent of this paper to base pedunculation on whether or not the "stalk precursor" is a separate and distinct secretion from that which forms the foot, but rather to point out that, despite its origin, region 6, where this secretion should be stretched, is lacking. The lack of this region has a pronounced effect on the ultimate elaboration of the spermatophores, for without it the arches are never truly "elevated above" the floor of the foot. That they may appear so in isolated cross sections of the vas deferens (Figs. 3, 4, 5) points to the need to consider both cross and longitudinal sections before statements concerning raised isolated ampullae can be made. Taken alone, Figure 3 and especially Figures 4 and 5 convey the erroneous impression that, indeed, the closed arches form isolated ampullae and that these are elevated on short stalks above the broad basal foot. In reality this is not true, as is seen when Figures 3, 4, and 5 are studied in relation to their position in the longitudinal section of the vas deferens (Fig. 2, regions 3, 4, 5).

This condition in *A. strigatus* and *A. maximus* is not new. Mouchet (1931) points out that the hermit crabs *Eupagurus bernhardus*, *E. prideauxi*, *E. cuanensis*, *Anapagurus hyndmanni*, and *Clibanarius misanthropus* likewise lack regions 4 and 6 in which the stalk is secreted and stretched. Although I have not investigated the spermatophoric development of these hermit crabs, it appears rather unlikely that distinct ampullae of sperm are elevated above the foot. If not, the spermatophores of these hermit crabs should be included with those of *A. strigatus* and *A. maximus* as further evidence of non-pedunculate spermatophore formation in the Paguridae.

REFERENCES

CALMAN, W. T. 1909. *Crustacea. A Treatise on Zoology*. R. Lankester, ed. Part VII. Fascicle 3. 290 pp. A. and C. Black, London.

EDMONDSON, C. H. 1946. *Reef and Shore Fauna of Hawaii*. Spec. Pub. 22 (rev. ed.).

iii + 381 pp., 223 figs. Bernice P. Bishop Museum. Honolulu.

FOREST, JACQUES. 1952. Contributions à la revision des Crustacés Paguridae. 1. Le genre *Trizopagurus*. *Mus. Natl. d'Hist. Nat., Mém. Sér. A* 5(1): 1–40.

MATTHEWS, D. C. 1951. The origin, development, and nature of the spermatophoric mass of the spiny lobster, *Panulirus penicillatus* (Oliver). *Pacific Sci.* 5(4): 359–371.

——— 1953. The development of the pedunculate spermatophore of the hermit crab: *Dardanus asper* (De Haan). *Pacific Sci.* 7(3), 255–266.

——— 1954*a*. The development of the spermatophoric mass of the rock lobster, *Parribacus antarcticus* (Lund). *Pacific Sci.* 8(1): 28–34.

——— 1954*b*. The origin and development of the spermatophoric mass of a nephropsid lobster, *Enoplometopus occidentalis* (Randall). *Pacific Sci.* 8(2): 115–120.

——— 1954*c*. A comparative study of the spermatophores of three scyllarid lobsters (*Parribacus antarcticus*, *Scyllarides squammosus*, and *Scyllarus martensii*). *Quart. Jour. Micros. Sci.* 95(2): 205–215.

——— 1956. The probable method of fertilization in terrestrial hermit crabs based on a comparative study of spermatophores. *Pacific Sci.* 10(3): 303–309.

——— 1956. The origin of the spermatophoric mass of the sand crab, *Hippa pacifica*. *Quart. Jour. Micros. Sci.* 97(2): 257–268.

MOUCHET, S. 1931. Spermotophores des crustacés décapodes, anomures et brachyures et castration parasitaire chez quelques pagures. *Sta. Océanog. de Salammbô, Ann.* 6: 1–203.

Spiders from Some Pacific Islands, II[1]

B. J. MARPLES[2]

I AM INDEBTED to Dr. N. L. H. Krauss for the collection of spiders which is described here. The specimens, with the exception of a paratype of the male of *Leucauge ilatele* retained in my own collection, will be deposited in the Bernice P. Bishop Museum in Honolulu. The collection contains examples of some 40 species from Tahiti, Raiatea, Moorea, and Borabora in the Society Group; from Aitutaki in the Cook Islands; from Upolu and Savaii in Western Samoa; from Tongatabu and from several localities in Viti Levu in the Fiji Islands. Experience with other collections from the islands has shown that species which are common on one occasion may be rare or absent on another, and so it has seemed advisable to list the numbers of individuals collected from each locality, whether the species has been recorded previously or not. There are many new records, inasmuch as little or no collecting has been done in some islands. In some families identification can only be tentative until a thorough revision has been carried out. It has been felt in some cases that it is zoogeographically less confusing to erect new species or genera for island spiders, than to force them into, for example, continental Australian genera which are inadequately characterised. Attention is drawn to such doubtful cases in the text, and this should be borne in mind in any consideration of faunae. A great deal of work is still needed before we have an adequate picture of the spider fauna of the Pacific islands, and still more of its relation to those of adjacent land masses. Berland (1934*a* and *b*) has described the spiders of Tahiti and has also listed those known from Polynesia, together with their distribution. The spiders of Samoa were described by Marples (1955).

In the descriptions the measurements were made with an eyepiece micrometer and are given in millimetres. The leg indices are derived by dividing the length of each leg by the length of the carapace, and the tibial indices, which give a measure of the stoutness of the legs, by dividing the combined lengths of the tibia and patella by the proximal breadth of the patella. The eye measurements are given in direct scale readings, so indicate the proportions only.

LIST OF SPECIES RECORDED

FILISTATIDAE

Filistata bakeri. Tahiti.

ULOBORIDAE

Uloborus bistriatus. Samoa.
Uloborus geniculatus. Fiji.
Uloborus gibbosus. Samoa, Fiji.

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SICARIIDAE

Scytodes marmorata. Fiji.
Scytodes striatipes. Society Islands, Samoa.

CLUBIONIDAE

Chiracanthium spp. Society Islands, Samoa, Tonga.

SPARASSIDAE

Heteropoda venatoria. Aitutaki.

THOMISIDAE

Diaea praetexta. Samoa, Tonga, Fiji.

SALTICIDAE

Bavia aericeps. Society Islands, Aitutaki, Samoa, Fiji.
Savaiia punctata. Samoa.
Menemerus bivittatus. Society Islands, Samoa, Fiji.
Mollicia microphthalma. Society Islands, Aitutaki.
Plexippus paykulli. Fiji.
Sandalodes calvus. Society Islands.
Ascyltus pterygodes. Samoa, Fiji.
Athamas whitmei. Samoa.
Cytaea piscula. Samoa.
Thorellia ensifera. Society Islands, Aitutaki, Samoa.
Vitia albipalpis. Fiji.

THERIDIIDAE

Conopistha gracilis. Samoa.
Theridion albostriatum. Aitutaki, Fiji.
Theridion kraussi. Fiji.

TETRAGNATHIDAE

Tetragnatha keyserlingi. Society Islands, Samoa.
Tetragnatha laqueata. Society Islands.
Tetragnatha macilenta. Samoa, Fiji.
Tetragnatha nitens. Society Islands.
Tetragnatha panopea. Society Islands, Samoa.
Leucauge granulata. Samoa.
Leucauge ilatele. Samoa.
Leucauge prodiga. Samoa, Fiji.
Leucauge tuberculata. Society Islands, Samoa.

EPEIRIDAE

Anepsia rhomboides. Samoa.
Argiope pentagona. Fiji.
Cyclosa littoralis. Samoa.
Epeira flavopunctata. Fiji.
Epeira pogisa. Samoa.
Epeira theisi. Society Islands, Samoa, Fiji.

FILISTATIDAE

Filistata bakeri Berland

1 ♀ Papeete, Tahiti. First record for the Society Islands. Previously recorded from the New Hebrides, Samoa, the Austral, Phoenix, and Christmas islands.

ULOBORIDAE

Uloborus bistriatus L. Koch

1 ♀ Sili, Savaii, Western Samoa. First record for Savaii, but it is common in Upolu and occurs also in Fiji.

Uloborus geniculatus Olivier

A widespread species throughout the tropics. Specimens from Viti Levu, Fiji: 2 ♀ Naliumba, 1 ♀ Korolevu, 1 ♀ Suva.

Uloborus gibbosus L. Koch

1 ♀ Savaii, the first record. 2 ♀ Upolu, 5 ♀ Lami, Viti Levu.

SICARIIDAE

Scytodes marmorata L. Koch

1 ♂, 2 ♀ Singatoka and Korolevu, Viti Levu. The first record for Fiji. Previously recorded from New Caledonia, Samoa, Tahiti, and Hawaii.

Scytodes striatipes L. Koch

1 ♀ Raiatea. The first record for Raiatea, but a widespread species already recorded from the Society Islands. 1 ♀ Upolu.

CLUBIONIDAE

Fourteen specimens are included in the collection, but only 3 seem certainly to be mature. All appear to belong to the genus *Chiracanthium*, of which 7 species have been described from the area, but in no case could the present specimens be certainly identified. The figures given by Koch for epigyna are difficult to compare with actual specimens. The teeth on the margins of the cheliceral groove also do not correspond, and Berland (1938) states that, in *C. longimanum* at least, they are variable. In the present series the numbers of teeth vary from 3 to 5 on the promargin, and from 2 to 4 on the retromargin. A tentative identification is 1 ♀ *C. furax* L. Koch from Nukualofa, Tongatabu, though the dark mark on the carapace is not present. This would be a new record, the species being described from Samoa. Another is 1 ♀ *C. gilvum* L. Koch from Raiatea. This species has been recorded from Australia, New Caledonia, New Hebrides, and Samoa. The 14 specimens were collected as follows: 1 from Raiatea, 1 from Borabora, 4 from Upolu, 3 from Tonga and 1 from Fiji.

SPARASSIDAE

Heteropoda venatoria (Linn.)

1 ♀ and 1 imm. Aitutaki, first record. This species has a worldwide distribution in tropical countries and is common in the Pacific area.

THOMISIDAE

Diaea praetexta L. Koch

All the Thomisids appear to be the same and to belong to this species. All however have little or no marking on the abdomen, but variation in this respect has been noted by Berland (1929). The records for Savaii 1 ♀, Nukualofa 2 ♀, and Viti Levu 11 ♀, are new.

SALTICIDAE

Bavia aericeps Simon

1 ♀ imm. Aitutaki, 1 ♀ imm. Sili, Savaii, 1 ♂ imm. Lomeri, Viti Levu. These are new records, the species having been recorded in Malaya and in various islands across the Pacific as far as the Marquesas. 1 imm. Tahiti, 1 ♀ and 1 imm. Raiatea.

Savaiia gen. nov.

Unidentate. Carapace low and flat, nearly twice as long as broad. Row of bristles with dark bases on each side of carapace and on the prolateral side of femur I. Spines on all legs. Resembles *Flacilla* Simon except that this is without spines.

Savaiia punctata sp. nov.

1 ♀ Savaii.

FEMALE. Length 5.49 mm. Carapace chestnut brown, darker in the ocular area and black around the eyes. Light patch at the thoracic groove. Chelicerae, maxillae and lip chestnut brown, legs and sternum pale brown. Abdomen pale brown with dark dorsal pattern. This consists of a pair of elongated patches followed by two pairs of square patches partially joined middorsally, followed by a single dorsal patch immediately anterior to the anal tubercle and spinnerets which are dark.

Carapace: Length 2.01 mm., breadth 1.30 mm., breadth of anterior row of eyes 0.94 mm. Low, flat dorsally and slightly widest at the level of legs III. Posterior slope gradual, no clypeus. On each side in the pale area below the eyes, and extending the whole length of the ocular area, is a row of 10 bristles arising from dark sockets.

Eyes: Ocular quadrangle slightly wider behind. Anterior row, seen from in front, slightly recurved. Ratios of the diameters of the eyes and of their distances apart: AM, 171; AL, 91; PM, 43; PL, 105; AM-AM, 46; AM-AL, 23; AL-PM, 138; PM-PM, 553; PM-PL, 108; L-L, 288; PL-PL, 542; overall breadth of anterior row, 583; overall breadth of third row, 642.

Chelicerae: Small, with pale hairs on the prolateral surface. Groove oblique. A single pointed tooth centrally placed on the retromargin of the groove, two teeth close together at the ventral end of the promargin.

Maxillae: Converging but not meeting, rounded anteriorly.

Lip: Longer than broad, narrower anteriorly.

Sternum: Length 0.87 mm., breadth 0.46 mm., oval.

Palp: The claw appears spoon shaped and is turned prolaterally at right angles to the axis of the tarsus. The palp is covered with pale hairs and there are three dark bristles on the patella and one on the tibia.

Legs:	IV	I	III	II	Palp
	1.67	1.32	1.23	1.16	0.54

	FEMUR	PATELLA AND TIBIA	META-TARSUS	TARSUS	TOTAL
Palp	0.47	9.36	...	0.26	1.09
I	0.90	1.07	0.43	0.26	2.66
II	0.79	0.89	0.38	0.28	2.34
III	0.78	0.92	0.46	0.32	2.48
IV	1.05	1.25	0.66	0.41	3.37

Tibial Index I 3.5
Tibial Index IV 6.2

Leg I much the stoutest especially the femur which is somewhat flattened and expanded dorsoventrally. On the prolateral surface at the distal end is a row of 6 hairs arising from dark sockets, appearing at first sight like a black line. Claws with 2 pectinations. Spines: Metatarsi; I, 2 proventral, 1 retroventral; II, 1 proventral, 1 retroventral; III and IV, 5 spines arranged around the distal end. Tibiae: I, 1 prolateral; II, none; III, 1 proventral, 1 retrolateral; IV, 1 proventral, 1 retroventral and 1 retrolateral. Femora with 3 dorsal and 1 prodorsal stout bristles. Trichobothria in a single row on the tarsi and metatarsi and a double row on the tibiae.

Abdomen: Length 3.03 mm., breadth 1.76 mm. Elongated oval, epigynum as in Figure 1.

FIG. 1. *Savaiia punctata*. Epigynum.

Menemerus bivittatus Dufour

1♂ Korolevu, Viti Levu. A widespread species not apparently recorded previously from Fiji. 1♂, 2♀ Tahiti; 1♂, 1♀ Upolu.

Mollicia microphthalma (L. Koch)

1♂, 1♀ and 3 imm. Papeete, Tahiti. 1♂ from the mountains near Uturoa, Raiatea. 1♂ Akaiami, Aitutaki. The specimen from Raiatea is larger than the others. The species is known from New Caledonia, and the Loyalty Islands in the west, and from Rarotonga, Tahiti, the Marquesas, and Hawaii.

Plexippus payculli Audouin

1♀ RakiRaki, Viti Levu, first record from Fiji. A cosmopolitan species known from many parts of the Pacific.

Sandalodes calvus Simon

1♀ Huahine. First record from Huahine though it is known from others of the Society Islands. 1♂, 1♀ Tahiti; 12♀ Raiatea.

Ascyltus pterygodes (L. Koch)

1♂, 3♀ and 5 imm. Sili, Palauli and Tapuelele, Savaii. 2♂, 1♀ and 2 imm. Kolo-i-Suva, Korolevu, Lami and Nandarivatu, Viti Levu. Known previously from Tahiti and Upolu. 1 immature male from Lautoka, Viti Levu, may belong to another species, two of which

in this genus have been described from Fiji. Some of the females from Savaii are much smaller than usual but seem to belong to this species. 12 ♀ Upolu.

Athamas whitmei Cambridge

1♂ Upolu.

Cytaea piscula L. Koch

4♂ and 1♀ Sili and Palauli, Savaii. New record. Previously known from Upolu, Tutuila and Australia. 5♂ Upolu.

Thorellia ensifera (Thorell)

6♂ and 2 imm., 5♀ Papeete, Tahiti. 1♀ Raiatea. 1♂ Akaiami, Aitutaki. 1♂ Upolu. It is a common and widespread species, but not previously recorded from Tahiti or Aitutaki.

Vitia gen. nov.

Fissidentate. Carapace moderately high and rounded. Palp of male long and slender with simple bulb and small apophysis.

Vitia albipalpis sp. nov.

1♂ RakiRaki, Viti Levu.

MALE. Length 5.05 mm. Carapace dark reddish brown shading to black around the eyes. Behind the eyes is a crescent-shaped area of lighter chestnut brown, its points anterior to the ALE, the broad central part extending from the level of the PLE more than half way towards the posterior margin of the carapace. Chelicerae and maxillae chestnut brown, legs darker brown especially the anterior pair. Palps brown except for the distal end of the femur, the dorsal and prolateral surfaces of the patella and the prolateral surface of the tibia. These are thickly covered with white hairs, longest on the tibia. Abdomen brown with darker mottlings and a white recurved crescent anterodorsally. Ventral surface pale.

Carapace: Length 2.67 mm., breadth 1.98 mm., breadth of anterior row of eyes 1.73 mm. Moderately high, slightly rounded in outline. Thoracic groove a black line, its anterior end level with the black of the PLE. Few bristles around the eyes.

Eyes: Anterior row recurved. Ocular quadrangle slightly wider in front. Ratios of the diameters of the eyes and of their distances apart: AM, 300; AL, 188; PM, 47; PL, 166; AM-AM, 22; AM-AL, 50; AL-PM, 234; PM-PM, 870; PM-PL, 146; PL-PL, 761; L-L, 420; clypeus, 92; overall breadth of anterior row, 1000; overall breadth of third row, 972.

Chelicerae: A bifid tooth on each margin of the groove, the prolateral being the larger and wide at the base, the retrolateral constricted at the base.

Maxillae: Slightly converging, wider and evenly rounded anteriorly.

Lip: Longer than broad, concave at the tip.

Sternum: Length 0.91 mm., breadth 0.74

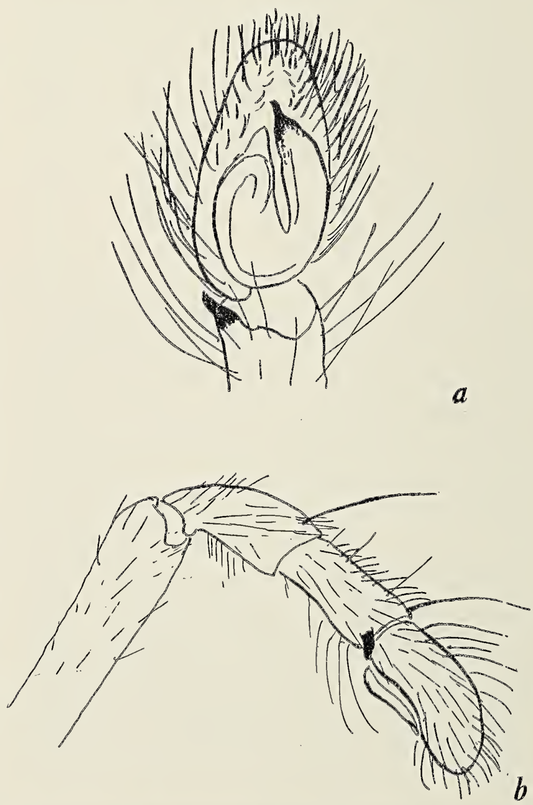

FIG. 2. *Vitia albipalpis*. *a*. Ventral view of right palp. *b*. Retrolateral view of right palp.

mm. Blunt behind, margin concave opposite coxae III and IV.

Palp: As in Figure 2. Rather long and slender with the tarsus little swollen. Short retrolateral apophysis at the distal end of the tibia. The conspicuous white hairs on the palp have been mentioned above.

Legs:	III	IV	I	II	Palp
	2.03	2.00	1.99	1.73	0.88

	FEMUR	PATELLA AND TIBIA	META-TARSUS	TARSUS	TOTAL
Palp	0.80	0.96	...	0.59	2.35
I	1.61	2.27	0.93	0.50	5.31
II	1.51	1.84	0.75	0.54	4.64
III	1.77	1.87	1.17	0.60	5.41
IV	1.53	1.82	1.38	0.63	5.36

Tibial Index I 6.1
Tibial Index IV 6.0

Claws: The retro with 4–6 large pectinations, the pro with 3 or 4 minute ones in addition at the proximal end of the row. Spines: Metatarsi I and II with 2 pairs, III with a circlet of spines at each end, IV with spines in the middle as well as at the ends. Tibiae: I, 3 pairs and 1 proximal prolateral: II, 2 prolateral, 2 pairs and 1 proximal retroventral; III and IV, 1 distal pair and 1 proventral, 3 pro and 3 retrolateral, 1 proximal dorsal. Patellae: I and II, 1 prolateral; III and IV, 1 pro and 1 retrolateral. Femora: 1, transverse distal dorsal row of 3 followed by 2 dorsal. II, III and IV have 4 in the transverse row. Trichobothria: In a single row on tarsi and metatarsi and a double row on tibiae.

Abdomen: Length 2.39 mm., breadth 1.52 mm. Ovoid.

This spider resembles some from Australia placed by Koch in several poorly characterized genera. It seems best to place it in a new genus until the position is clearer, rather than to suggest on doubtful grounds a faunal affinity between Fiji and Australia.

THERIDIIDAE

Conopistha gracilis (L. Koch)

1 ♀ Savaii. 1 ♀ Upolu.

Theridion albostriatum L. Koch

1 ♂ Aitutaki. 1 ♂, 1 ♀ Korolevu, Viti Levu. These specimens are somewhat doubtfully placed in this species, recorded from Australia and Tonga. They appear to be the same as some collected in buildings in Upolu (Marples 1955) and also tentatively placed here.

Theridion kraussi sp. nov.

1 ♀ Kolo-i-Suva, Viti Levu.

FEMALE. Length 4.58 mm. Colour brown, abdomen lighter in front and on the sides. Sternum with 3 lateral and a posterior median dark marks.

Carapace: Length 1.54 mm., breadth 1.24 mm. Heart-shaped, the cephalic part projecting forward with prominent eyes, AME overhanging the clypeus, thoracic part domed. Smooth surface with some scattered bristles almost all on the cephalic part.

Eyes: 8. AME dark, the remainder light with reddish pigment. From above the anterior row strongly recurved, posterior row straight. Breadth of eye group 0.56 mm. Ratios of the diameters of the eyes and of their distances apart: AM, 193; AL, 142; PM, 164; PL, 163; AM-AM, 135; AM-AL, 46; AM-PM, 182; PM-PM, 147; PM-PL, 138; L-L, 0; clypeus, 365.

Chelicerae: Slender, joined at base, no boss. 3 teeth on the promargin of the groove.

Maxillae: Long, very much longer than the lip, converging but not meeting. Scopula on median margin and anterior median angle. Black serrula lateral to it.

Lip: Twice as broad as long.

Sternum: Length 0.88 mm., breadth 0.79 mm. Three slight indentations on each side. Posterior blunt point between coxae IV which are well separated.

Palp: Claw with 4 pectinations and pectinated bristles on the tarsus. Two pairs of trichobothria on the tibia. Tarsal organ 24 per cent of the length of the tarsus from its distal end.

Legs:	I	IV	II	III	Palp
	4.43	3.58	3.41	2.50	0.81

	FEMUR	PATELLA AND TIBIA	META-TARSUS	TARSUS	TOTAL
Palp	0.37	0.41	...	0.48	1.26
I	2.08	2.14	1.87	0.78	6.87
II	1.67	1.56	1.41	0.65	5.29
III	1.21	1.08	1.01	0.57	3.87
IV	1.74	1.71	1.42	0.67	5.54

Tibial Index I 10.1
Tibial Index IV 8.4

Three claws, the dorsal ones with 3 or 4, the median one with 1 pectination. Spurious claws, except on IV, and pectinated bristles. Bristles, pectinated on both sides, along tarsus and the distal end of metatarsus IV. No spines. Tarsal organ on I, 63 per cent of the length of the tarsus from the distal end.

Abdomen: Length 3.11 mm., breadth 2.47 mm. Rounded, spinnerets ventral. Anterior spinnerets largest, and close together. Other spinnerets in a transverse line, the median small and compressed between the posterior ones. Anal tubercle small and transverse, no colulus. Epigynum as in Figure 3.

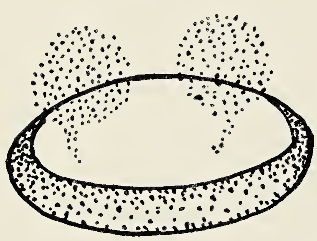

FIG. 3. *Theridion kraussi.* Epigynum.

The presence of teeth on the cheliceral groove may exclude this species from the genus *Theridion*, but it seems best to place it here tentatively.

TETRAGNATHIDAE

Several species of *Tetragnatha* have been recorded from the South Pacific area, but they seem to be subject to a considerable amount of variation in colour, in the size and position of the eyes, and in the cheliceral teeth. The following identifications are accordingly more or less uncertain.

Tetragnatha keyserlingi Simon

2♂, 3♀ from Tahiti. These differ from the descriptions in colour and in the cheliceral teeth and are only very doubtfully placed here. 1♂ Raiatea. 2♂, 1♀ Upolu.

Tetragnatha laqueata L. Koch

1♀ from Opoa, Raiatea. Previously recorded only from Samoa.

Tetragnatha macilenta L. Koch

1♂ from Lami, Viti Levu, a new record. 12♀ Upolu, 1♂, 4♀ Savaii.

Tetragnatha nitens (Audouin)

1♀ from Baie de Cook, Moorea. This is a species with a very wide distribution, from the Mediterranean to several of the Pacific islands.

Tetragnatha panopea L. Koch

1♀ from Borabora. Previously recorded from Lord Howe Island, the New Hebrides, Ellice Islands, and Samoa. 1♀ Savaii.

Leucauge granulata Walckenaer

According to Dalmas (1917) the species referred to by L. Koch as *Leucauge granulata* Walck. is not properly so called but should be *Leucauge dromedaria* (Thorell). It occurs in Australia, New Zealand, and several of the Pacific islands as far east as Tahiti. It has not been recorded from Samoa. One specimen in the present collection from Sili, in Savaii, may belong to it. It resembles New Zealand specimens in shape and colour, but it is considerably smaller.

Leucauge ilatele Marples

2♂ Apia, Upolu. Described from the female only from Upolu.

MALE. Length 3.84 mm. Pale yellowish

brown, the abdomen covered with smaller silvery marks leaving a clear dorsal stripe. Brown round the eyes and at the thoracic groove.

Carapace: Length 1.76 mm., breadth 1.40 mm., breadth of eye group 0.63 mm. Low, with longitudinal groove smooth pear-shaped outline.

Eyes: 8, all pale. From above, anterior row strongly recurved, posterior row straight. Ratios of the diameters of the eyes and of their distances apart: AM, 135; AL, 145; PM, 160; PL, 166; AM-AM, 131; AM-AL, 117; AM-PM, 133; PM-PM, 107; PM-PL, 130; L-L, 0; clypeus, 205.

Chelicerae: Groove oblique, 3 promarginal and 4 retromarginal teeth, the proximal ones of each row situated on the rim of the articular membrane, which is large, of the fang. A blunt tooth retrolaterally placed near the last retromarginal tooth.

Maxillae: Wider distally and curving outwards.

Lip: Broader than long, truncated anteriorly where it is rebordered and has 2 bristles at each corner.

Sternum: Length 0.72 mm., breadth 0.87 mm. Heart-shaped. Margin convex and rebordered opposite coxae I, slightly concave opposite the other coxae. Extends between coxae IV as a slender process bifurcated at the waist.

Palp: As in Figure 4. Large bulb, cymbium with 2 apophyses at the proximal end, one blunt and directed dorsally, one sharp and curved and directed prolaterally.

Legs:	I	II	IV	III	Palp
	7.85	4.67	3.87	2.25	1.27

	FEMUR	PATELLA AND TIBIA	META-TARSUS	TARSUS	TOTAL
Palp	1.03	3.84	...	0.82	5.69
I	3.75	4.61	4.37	1.07	13.80
II	2.42	2.58	2.47	0.73	8.20
III	1.28	1.16	1.04	0.48	3.96
IV	2.29	2.12	1.85	0.52	6.80

Tibial Index I 18.1
Tibial Index IV 12.3

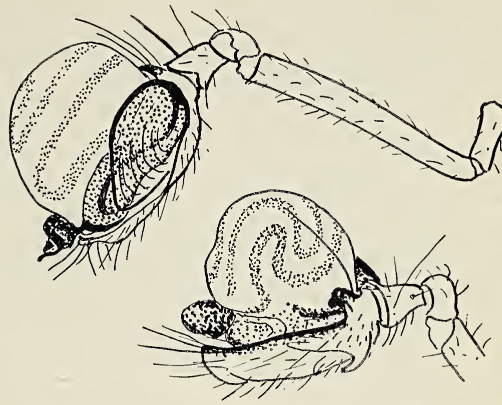

FIG. 4. *Leucauge ilatele*. *a*. Retrolateral view of left palp. *b*. Prolateral view of right palp.

Many of the spines are missing from these specimens but they seem to have been fewer than in the female. Five small trichobothria in two rows on the prolateral side of the base of femur IV.

Abdomen: Length 2.14 mm., breadth 1.22 mm. Slight dorsal hump about one third of the length from the anterior end.

Leucauge prodiga L. Koch

1 ♀ Lami, Viti Levu. Previously recorded from Samoa. 2 ♀ Upolu, 2 ♀ Savaii.

Leucauge tuberculata Keyserling

3 ♀ from the mountains near Uturoa, Raiatea, 1 ♀ from Baie de Cook, Moorea. First records from the Society Islands, previously recorded from Fiji, Samoa, and Tonga. 2♂, 5 ♀ Savaii. 8 ♀ Upolu.

EPEIRIDAE

Anepsia rhomboides L. Koch

5 ♀ Sili, Savaii. The first record, but the species is common in Upolu. 11 ♀ Upolu.

Argiope pentagona L. Koch

1 ♀ Lami, Viti Levu. Previously recorded from Ovalau, also in the Fiji Islands.

Cyclosa littoralis L. Koch

14 ♀ Savaii. First record. Common in Upolu and recorded also from Fiji. 1 ♀ Upolu.

Epeira flavopunctata L. Koch

1 ♂ from Nandarivatu, Viti Levu. This species was described from a single male from Fiji, and the present specimen agrees with it except in the pattern on the abdomen.

Epeira pogisa sp. nov.

1 ♀ Apia, Upolu.

FEMALE. Length 5.28 mm. Carapace, sternum, mouth parts, coxae and femora pale yellowish brown. Distal parts of legs darker and obscurely banded. Dorsal side of abdomen dark reddish brown mottled with light yellowish. Very little pattern, but an ill-defined median band of the dark colour, bordered with light. It is narrow in front but broadens about one third from the posterior end, at which point there is a procurved transverse band. Ventral side of abdomen and the spinnerets pale yellowish brown mottled with white behind the epigynum.

Carapace: Length 2.58 mm., breadth 2.05 mm., breadth of eye group 1.32 mm.

Eyes: From above, both rows recurved. Ratios of the diameters of the eyes and of their distances apart: AM, 177; AL, 165; PM, 157; PL, 144; AM-AM, 213; AM-AL, 400; AM-PM, 175; PM-PM, 146; PM-PL, 510; L-L, 0; clypeus, 95.

Chelicerae: 4 teeth on the promargin of the groove, the third from the fang being considerably the largest. 3 teeth on the retromargin.

Maxillae: Truncated anteriorly, ventral surface distinctly convex.

Lip: Broader than long.

Sternum: Length 1.08 mm., breadth 1.01 mm.

Palp: Claw with 9 pectinations.

Legs:	I	II	IV	III	Palp
	3.59	3.37	3.24	1.70	1.01

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.78	0.89	. . .	0.96	2.63
I	2.77	3.53	2.22	0.96	9.43
II	2.50	3.29	2.04	0.89	8.72
III	1.39	1.43	0.99	0.58	4.39
IV	2.38	2.60	2.72	0.68	8.38

Tibial Index I 9.2
Tibial Index IV 7.2

Claws: I, pectinations, pro 8, retro 10, median 2. Spines: I, metatarsus, 5 proventral, 3 retroventral, 1 retrolateral, 1 dorsal. Tibia, 3 proventral, 3 prolateral, 2 retroventral, 3 retrolateral, 3 dorsal. Patella, 2 prodorsal, 2 dorsal, 2 retrodorsal. Femur, 3 proventral, 1 prolateral, 2 dorsal, 1 retrodorsal. II, metatarsus, 4 proventral, 2 dorsal, 3 retroventral, 1 retrolateral. Tibia, 2 proventral, 4 prolateral, 2 dorsal, 3 retroventral, 1 retrolateral. Patella, as in I. Femur, 1 prodorsal, 1 dorsal, 1 retrodorsal. III, no spines, some stouter bristles. IV, metatarsus, 3 proventral, 4 retroventral. Tibia, 1 ventral, 2 retroventral, 2 dorsal, 3 prodorsal, 3 retrodorsal. Patella, 1 prodorsal, 1 retrodorsal. Femur, 1 prodorsal, 1 dorsal, 1 retrodorsal.

Abdomen: Length 3.23 mm., breadth 2.39 mm. Covered with short pale hairs and long dark bristles. Epigynum a dark conspicuous broad-ended projection, as in Figure 5.

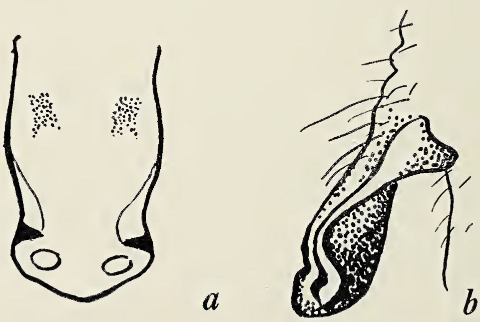

FIG. 5. *Epeira pogisa*. *a*. Ventral view of epigynum. *b*. View of epigynum from left side.

Five species of *Epeira* were recorded from Samoa by Koch. Berland recorded three of them in 1929, one represented in his collection by only a single specimen, and stated that *E. maculaticeps* appeared to be the most widespread species. As a result of four months collecting in 1945–46 and 1950–51 I obtained 93 specimens from many localities in Upolu and off-lying islets, all of which appeared to be *E. theisi*. The present specimen corresponds with none of these species, and as far as I can determine it appears to be new. The name suggested is the Samoan word for "dark," with reference to the colour.

Epeira theisi Walckenaer

This is a widespread tropical species found in many Pacific islands. In the present collection there are specimens from Tahiti, Raiatea, Borabora, Upolu, Savaii, and Viti Levu.

SUMMARY

A collection of some 40 species of spiders from the Society Islands, Aitutaki, Western Samoa, Tonga, and Fiji is described. Two new genera and four new species are proposed as follows: Salticidae, *Savaiia punctata* and *Vitia albipalpis*, Theridiidae, *Theridion kraussi*, Epeiridae, *Epeira pogisa*. The male of *Leucauge ilatele* Marples is also described. There are many new distributional records, especially from Aitutaki, which has no previous records, and from Savaii and Viti Levu, which have few.

REFERENCES

BERLAND, L. 1929. Araignées (Araneida). IN *Insects of Samoa*, Pt. 8: 35–78. Brit. Mus. Nat. Hist. London.

——— 1934*a*. Les Araignées du Pacifique. IN Contribution a étude du peuplement zoologique et botanique des îles du Pacifique. *Soc. Biogéog., Pub.* 4: 155–180.

——— 1934*b*. Les Araignées de Tahiti. *Bernice P. Bishop Mus., Bul.* 113: 97–107.

——— 1938. Araignées des Nouvelles Hébrides. *Soc. Ent. de France, Ann.* 107(2): 121–190.

DALMAS, R. DE. 1917. Araignées de Nouvelle Zélande. *Soc. Ent. de France, Ann.* 86: 317–430.

KOCH, L., and E. KEYSERLING. 1871–1889. *Die Arachniden Australiens*. Nurnberg.

MARPLES, B. J. 1955. Spiders from Western Samoa. *Linn. Soc. London, Jour., Zool.* 42: 453–504.

Studies on the Johnstonianidae (Acari, Parasitengona)

Irwin M. Newell[1]

The subfamily Johnstonianinae Thor 1935 (Trombidiidae) was established to include *Johnstoniana* George 1909 and related genera. The only comprehensive treatment of the group was published by Thor and Willmann (1947) who included eight species in the genera *Centrotrombidium* Kramer 1896, *Johnstoniana*, *Diplothrombium* Berlese 1910, *Myrmicotrombium* Womersley 1934, and *Hirstithrombium* Oudemans 1928.

The present study was undertaken with a view to placing the systematics of the Johnstonianinae on a sound morphological basis, and to determine the relationship of the group to other terrestrial Parasitengona. It soon became apparent that the mites included in the Johnstonianinae differed so significantly from other terrestrial Parasitengona that they could not logically be retained within the family Trombidiidae Murray 1877.[2] The differences are much greater than those which have been cited, for example, to establish Trombiculidae Ewing 1944 as a family separate from the Trombidiidae. The group is therefore raised to family rank with *Johnstoniana* George 1909 as the type genus.

Interest in the group was stimulated by numerous indications that this is perhaps the most primitive existing family, terrestrial or otherwise, within the Parasitengona. The indications of this are of ecological, behavioral, and morphological nature.

Ecologically the Johnstonianidae are terrestrial in larval, nymphal and adult stages, but are rarely found where there is not an ample supply of water nearby; in fact many of them could be aptly termed subaquatic. Thus, ecologically they are in a position from which they (or their antecedents) could evolve in two directions—either toward strictly terrestrial forms such as the Trombidiidae, or toward the subterrestrial aquatic mites such as the Limnocharidae, Thyasidae, etc., and thence to the more strictly aquatic Parasitengona. From an evolutionary standpoint, it might be hypothesized that the Parasitengona parasitic on insects evolved before those on terrestrial vertebrates, because insects appeared first in the fossil record. This assumes that there were appropriate predatory Acari present when the hosts appeared, but since the earliest fossil record of the Trombidiformes (*Protacarus* Hirst, Devonian) is at least contemporaneous with that of the earliest known Insecta, this is not an impossible assumption. The next major group of hosts to become available to the Parasitengona were the Amphibia, and the seemingly close structural similarities between *Hannemania* species (which largely parasitize Amphibia) and the Johnstonianidae, which parasitize insects living in moist habitats, is suggestive that these are phylogenetically very close. This close relationship could have arisen in more than one way—either by the direct descent of the Amphibia-parasites from the early Johnstonianidae, or by simultaneous radiation of the Amphibia-parasites and the Johnstonianidae from a common ancestral mite or group of mites which appeared at the same time as or somewhat later than the Amphibia. The extent to which the Parasitengona have become adapted to the Insecta

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[2] While many derivatives of the name *Trombidium* Fabricius 1775 were published prior to 1876 (see Oudemans 1937: 1349–1361), the first unequivocal use of the name Trombidiidae appears to be that of Murray (1876) in his Economic Entomology. Accordingly the writer ascribes the family name to Murray 1876 rather than to Leach 1815, who employed the name Trombidides, and not Trombidiidae.

would suggest that the only thing that might possibly have prevented the parallel emergence of the latter two groups would have been the unavailability of a suitable prototype mite at the time the insects were first becoming established. The groups with larvae parasitic on higher vertebrates appear to be more modified than the Johnstonianidae and *Hannemania* (although not more so than the Trombidiidae or Erythraeidae which parasitize insects).

So far as their habits are concerned, the larvae of the Johnstonianidae are all parasitic, but the relationship between larva and host is very loose. Among the Parasitengona there are two extremes in the relationship of larva to host—in some species the larva is little more than a predator, preying upon a number of host individuals during its development, and detaching readily when disturbed. At the other extreme we find larvae which, once firmly attached, remain with the host until they complete their larval development almost regardless of what stimuli may intervene. A simple test of the degree of host fixity is to drop the host with the attached larvae into a vial of 60 per cent alcohol. Forms in which host fixity is highly developed will usually remain attached, unless they had not become firmly attached to the host or unless they were in the process of detaching themselves at the time of capture. Forms in the other group detach readily regardless of how long they have been on the host, and for this reason they are called "self-detaching larvae." All Johnstonianidae which the author has studied in the living state have larvae of the self-detaching type.

Morphologically they appear to be more generalized than other Parasitengona. For example, there are two pairs of sensilla on the scutum in most species, such as are found in the Erythraeidae and most Smarididae, but with obvious trends toward modification or loss of the anterior pair as in the Trombidiidae and Trombiculidae. The simplicity of the body setae and those of most leg segments would appear to be a primitive characteristic contrasting with the more ornate setae found in other families. The possession of a large complement of supracoxal, vestigial, and rostral setae would also seem to be primary in the Parasitengona, secondary reductions in these being most notable in the Trombidiidae and Trombiculidae. It should be pointed out, however, that notable differences in these occur within the limits of the family. The possession of well-developed paragenital sclerites also seems to be a primitive characteristic. These are probably found in all genera of terrestrial Parasitengona, although in many they lack setae and are nearly invisible. The generalized structure of the palpal tarsus of the larva, and the presence of a single subterminal spiniform seta on the adult palpal tibia, appear in sharp contrast to the greatly reduced tarsus of the larvae of the Trombidiidae, and to the elaborately developed ctenidium of the adults of many genera outside of the Johnstonianidae. These are some of the principal morphological indications of the primitive nature of the group. The detailed morphology of these and other structures will be discussed below, along with others not mentioned here.

ACKNOWLEDGMENTS

The present study was initiated under a contract between the Office of Naval Research (Nonr-782(00), and the University of Hawaii while the writer was on the staff of the Hawaii Agricultural Experiment Station. It was continued under a research grant (NSF-G1833) from the National Science Foundation to the University of California. Much of the work, including the field study program for 1953, has been supported by research grants from the University of California. Without the assistance of these foundations and institutions, the present work would have been most improbable.

Mari Riess of the University of California at Riverside made about 200 of the camera lucida drawings; while the remainder were

done by Helen Au Randall, formerly of the University of Hawaii. In these figures, the scales provided are marked in 10 μ units, except for the few marked in 100 μ units. The latter are drawn with a double base line, and also have the total length indicated on the scale.

This is not intended to be an exhaustive review of the species assignable to the family. While such might be desirable, as a matter of fact existing descriptions are so inadequate that a thorough review of the group is impossible until all species have been redescribed. Only where it was felt that a specific contribution to knowledge could be made on the basis of the descriptive material available has mention been made of previously named forms. For example, the genus *Polydiscia* Methlagl is shown to belong in the family, at least provisionally, and a brief mention of *Crossothrombium* Womersley, omitted from recent catalogues, is included to bring it to the attention of other workers who might also overlook it.

MORPHOLOGY

In describing these and other mites, the writer has found it useful to develop a system of notation of the position of specialized setae or other features on the segments of the legs and palpi. It is frequently necessary to indicate the precise position of these, but at present there is no brief, convenient method for doing so. The system will be illustrated by an example. The position of the seta or other structure is stated with reference to the proximal and distal ends of the segment. For instance, the statement "tarsus II with a spikelike famulus at 0.61*pd*" means that famulus$_2$ is located at a point 0.61 of the length of the tarsus from the proximal end, and on the posterodorsal aspect of the segment. The terms dorsal, ventral, anterior, and posterior, are utilized to express position with relationship to the longitudinal axis of the legs. The terms lateral and medial are not employed, since the meaning of these terms is reversed on legs I and II as compared with III and IV. The reader should visualize the legs as protruding from the sides of the body at right angles to the main axis of the body. For the sake of morphological uniformity, the same orientation should be visualized in the case of the pedipalps despite the seeming incongruity of the pedipalps of a mite projecting at right angles to the median axis of the body. The terms preaxial and postaxial are in some respects preferable to anterior and posterior, in referring to the segments of appendages, but the writer prefers to use anterior and posterior because the symbols *a* and *p* are immediately understandable, avoiding the necessity of using either two-letter symbols, or others which are less readily comprehensible. In the following descriptive accounts, the symbol *a* following a decimal in the designation of the position of a particular seta or structure means anterior, *p* = posterior, *d* = dorsal, *v* = ventral, *ad* = anterodorsal, *pd* = posterodorsal, *av* = anteroventral, and *pv* = posteroventral. This method of notation greatly simplifies the problem of precise location of setae, and also makes it possible to analyze variation in the positions of specific setae. By the use of special graphical methods it is possible to directly determine the positions of the specialized setae with ease and rapidity, without the necessity of making measurements and converting these to decimals.

In naming the specialized setae of the appendages, the writer has adopted the system first propounded by Grandjean, beginning in 1935. The only modification was the addition of a system of notations for the several types of solenidia found on the legs. The Grandjean system of setal nomenclature is based primarily upon the form and physical properties of the setae, rather than upon their position. The solenidia are thin-walled setae showing spiral or annular internal structure in most types, although some solenidia do not show any internal structure. Typically the

solenidia taper very little throughout their length, and the distal end is usually rounded. Ornamentation is almost invariably wanting, and the cuticle is optically inert in polarized light. The eupathidia are similar to the solenidia in certain respects, but there is usually no internal structure (an exception is illustrated in Fig. 238). External ornamentation is more likely to be found than in the solenidia, in the form of short barbs (Figs. 215, 216, 217) and the cuticle is nearly always partially anisotropic. Birefringence is most noticeable in the basal portion. The walls of the eupathidia are typically of uniform thickness throughout —slightly thicker than the solenidia and thinner, relatively, than the normal setae. Notable transformations in structure of the eupathidia are found in certain cases, as in those on the tarsus of the palp. For example, in the genera *Centrotrombidium*, *Johnstoniana*, and *Diplothrombium*, typical eupathidia are found on the palpal tarsus of the adult (Figs. 59, 83, 159), while in the larva the apparent ontogenic forerunners of these are heavy, pectinate, sometimes elaborately formed setae, with little or no trace of a central canal (Figs. 29, 92, 132).

The other types of setae provide no particular difficulties in interpretation and will be discussed below with reference to their characteristics and distribution in the Johnstonianidae.

Scutum

A number of interesting and illuminating trends can be seen in the structure and chaetotaxy of the scutum of the Johnstonianidae. The first is a reduction or a modification of the anterior pair of sensilla, leading to their eventual disappearance, or their transformation into setae which are not at all sensillar in form. While it might be argued that the trend is the reverse, that is, toward the development of the anterior pair of sensilla, this does not appear to be the most likely alternative. In *Johnstoniana* there is a well defined anterior pair of sensilla in both larva and adult (Figs. 70, 90). Also, in the larva of *Lassenia scutellata* there is a well defined anterior pair of sensilla, borne on a small sclerite separated from the remainder of the scutum by a narrow band of striated membranous cuticle (Fig. 249). In the adults of *Lassenia spinifera*, these anterior setae (Fig. 232) are scarcely recognizable as sensilla because the alveoli are not to any sensible degree different from those of the other setae of the scutum. But there is little doubt that the two short simple setae on the spine of the adult scutum actually are the anterior sensilla. In the larva of *Lassenia lasseni* the anterior sensilla are present, although the alveoli of these are not as well developed as the alveoli of the posterior pair of sensilla (Fig. 214). Nevertheless these are unquestionably the anterior sensilla. They are short and distinctly barbed, in marked contrast to the posterior pair which are long, slender, and smooth. In fact the anterior sensilla more closely resemble the other setae on the scutum than they do the posterior sensilla. In the adult of the species (Fig. 183) there is only one well defined pair of sensilla. At the same time there is usually a pair of stiff, rodlike setae near the anterior margin of the scutum, somewhat set apart from the rest of the setae. If one were to examine only the nymphs and adults of *Lassenia lasseni* there would be considerable justification in stating that this species was characterized by the possession of a single pair of sensilla. Yet there is no doubt that the anterior two rodlike setae on the adult scutum are derived from the anterior sensilla of the larva, and are therefore homologous with them, regardless of their remarkable transformation in form. Thus within the one genus *Lassenia* we see a partial obscuring of the anterior pair of sensilla between the larval and adult stages.

Genera in other families of Parasitengona should be re-examined to determine those in which the anteromedian setae of the scutum are homologous with the anterior sensilla for it is evident from the Johnstonianidae that this can be expected. Such is almost certainly

the case in *Hannemania*, *Leeuwenhoekia*, and related genera in which the resemblance to some of the Johnstonianidae is augmented by the possession of an anteromedian spine on the scutum. If these are homologous with the anterior sensilla, then it is further likely that the single anteromedian seta found in many of the Trombiculidae is also homologous with the anterior sensilla, which have somehow or other become fused. Only in such genera as *Gateria*, *Walchia*, *Gahrliepia* and *Schöngastiella* do the anterior sensilla (or their paired or unpaired homologues) appear to be totally lacking. The recognition of the essential unity of these setae at the anterior end of the scutum will help greatly in the analysis of evolutionary trends within the Parasitengona. The modifications of the anterior sensilla in the Johnstonianidae provide the key.

In *Diplothrombium monoense*, we find that it is the adult rather than the larva in which the anterior sensilla are best developed (Figs. 110, 129). And, finally, in *Centrotrombidium* the anterior sensilla are completely absent in both larva and the adult. Some authors have referred to the anterior pair of setae on the scutum of *Centrotrombidium* as a second pair of sensilla, but a comparison of Figures 4 and 110 will show that this is not the case; rather the anterior pair of setae in *Centrotrombidium* are undoubtedly the homologues of the setae which, in *Diplothrombium*, lie between the two pairs of sensilla; the anterior sensilla are totally lacking.

Another interesting variant is found in the degree of duplication of the setae of the scutum other than the sensilla. In *Centrotrombidium* and *Diplothrombium*, the setae anterior to the posterior sensilla undergo little or no reproduction in the transformation from the larva to adult, except perhaps in *D. micidium*. The larva of this species is as yet unknown (unless it should prove to be the larva described here as *D. cascadense*) so it is not possible to state positively whether or not there has been a duplication of these setae in this particular species. If we assume that the larva does have a single pair of setae between the anterior and posterior pairs of sensilla, which is probably the case, then there is a moderate degree of duplication of these setae (Fig. 160).

In *Diplothrombium monoense* there is a moderate degree of duplication of these setae as a rule, for there is usually a second pair of setae near the margin of the plate between the anterior and posterior pairs of sensilla (Fig. 110). Considering the situation in *D. micidium*, it is probable that these can be regarded as a duplication of the setae in question. The situation in *Johnstoniana* and *Lassenia* is somewhat more complex, for there are usually five to nine or more setae which we could regard as the ontogenic descendants of the intersensillar setae of the larva.

In addition to the chaetotactic features described above, there is a further variant in the structure of the scutum. In both *Centrotrombidium* and *Diplothrombium*, there is a noticeable tendency toward the formation of a posterior stalk with a feebly sclerotized lateral expansion in the adult (Figs. 4, 63, 110, 160). No corresponding development is found in the scutum of either *Lassenia* or *Johnstoniana*. Associated with the tendency toward the differentiation of the posterior lobe of the scutum, is the degree of development of the lateral portion of the scutum outside the crista. The broadest scutum is found in *Johnstoniana*, a somewhat narrower plate in *Lassenia*, and the narrowest scuta are found in *Diplothrombium* and *Centrotrombidium*.

There is also a noticeable difference in the crista metopica, for this structure is well developed in the larva of *Johnstoniana* and *Diplothrombium*, very feebly developed in the posterior part of the scutum of *Centrotrombidium*, and essentially absent from the larval scutum of *Lassenia*. A unique variant in the form of the posterior sensilla is found in *Centrotrombidium*, in which the distal portion of the shaft is greatly expanded and pyriform to spherical in form.

Corneae

The eyes of the Johnstonianidae show little variation. There are typically two well-developed corneae borne on a small ocular plate on either side of the scutum. While these frequently protrude prominently, they are not so well developed that they could be described as stalked, except in *Johnstoniana*, in which the ocular plates are definitely cylindrical and raised well above the surface of the propodosoma (Fig. 86). About the only variant in the form of the corneae is found in *Centrotrombidium*. In this genus only the anterior cornea is developed in the adults of the species known to the writer; the posterior cornea is represented by a prominent but nonhyaline protuberance (Fig. 53). In none of the forms seen by the writer are there any setae on the ocular plates, either in the larva or in the adult. According to Womersley, the eyes are absent in *Crossothrombium*.

Dorsal Setae of Hysterosoma

There are two outstanding features of the dorsal chaetotaxy of the Johnstonianidae. The first of these is the insertion of the dorsal setae of the larvae in individual sclerites which show no sign of fusion in any of the known forms. The second feature is the rather poor development of setal ornamentation, especially in the adults. As in the larva the setae of the adults are also borne on individual sclerites, although these are relatively smaller than in the larva. In all species studied, the dorsal setae in the adult are completely smooth, and are frequently stiff, short, and rodlike (Fig. 183). In the larva the setae are always arranged in four or five well defined rows (Fig. 131). The dorsal setigerous sclerites in the larva are always flat or weakly arched, but in the adult they are characteristically elevated, forming either low hemispheres or short cylindrical protuberances above the general surface of the cuticle (Fig. 64).

Dorsal Propodosomal Setae

In none of the known larvae are there any setae outside the scutum. In the adult however, there is a tendency toward the development of setae lateral to the scutum and even lateral to the ocular plate. In *Johnstoniana latiscuta* (Fig. 86) there are no setae whatever lateral to the scutum. In *Lassenia lasseni* there is a single pair of setae, or occasionally more, between the scutum and the ocular plate, but the great majority of the propodosoma outside of the scutum is bare (Fig. 183). The situation in *Lassenia spinifera* is somewhat different, for in this species there are quite a number of setae surrounding the ocular plate although these are by no means as abundant as on the dorsum of the hysterosoma; and moreover there is an appreciable difference in form between the dorsal setae of the propodosoma and hysterosoma (Fig. 232). In *Centrotrombidium* and *Diplothrombium*, there are generally several setae between the scutum and ocular plates, although again the density of setae here is in no way comparable with that on the dorsum of the hysterosoma.

Coxal Chaetotaxy of Larva

The situation with respect to this character is not entirely clear owing to the small number of species known in each of the genera. In each of the four species of *Centrotrombidium*, *Diplothrombium*, and *Johnstoniana* which have been adequately described there are two setae on coxa I and one seta on each of coxae III and IV (2–1–1). Only two species are known in the genus *Lassenia*, the coxae of *L. lasseni* having the setal formula 2–2–3, and *L. scutellata* having the setal formula 2–1–2. Thus it is possible that in the genus *Lassenia* the number of coxal setae in the larvae is only a specific character, while in the other thrree genera it may prove to be generically constant. The supracoxal setae of the legs are discussed below along with the other specialized setae of the appendages.

Pars Medialis Coxae

This is the name applied to the small extension of the medial angle of coxa I of most

adult terrestrial Parasitengona (Figs. 54, 82, 154, 192). In many cases, especially in the adult, it is difficult to tell whether this is a part of coxa I or II, or whether it is a distinct sclerotized area independent of the coxae. However, in those species in which coxae I and II are rather distinctly separated, and in which a distinct pars medialis coxae is developed, it is clear that this is an extension of the coxa of leg I. In those cases in which the relationship is not so clear, it is probably safe to assume that the pars medialis coxae is morphologically a part of coxa I rather than II.

The number of setae present on the pars medialis coxae is quite variable even within the limits of a given species. At best, variations in this structure appear to be of a specific rather than a generic nature. An interesting variant is found in the genus *Lassenia*, in which *L. lasseni* has a well-defined pars medialis coxae in the adult (Fig. 192) whereas in *L. spinifera* (Fig. 234) the pars is entirely absent. In the latter species there is a general reduction in the degree of sclerotization of the coxae for many of the setae which normally would be included within coxae II actually lie in the membranous cuticle immediately behind the posterior margin of these (Fig. 234). It is interesting to note that when there is a difference in the form of the setae of coxae I and the intercoxal area such as exists in *Diplothrombium micidium* (Fig. 154) and *Lassenia lasseni* (Fig. 192) the setae of the pars medialis coxae are more similar to those of the intercoxal area than they are to those of the coxae themselves.

Coxal Ring

In the Parasitengona, the coxae have become largely incorporated into the ventrolateral body wall as a series of well-defined plates. However, if one examines the distal portion of the typical coxa of an adult it is found that this comprises a cylinder of extremely short length, and it is this peripheral portion which the author refers to as the coxal ring. The distal portion of the coxa is ringlike in the adults of most species of terrestrial Parasitengona, except for leg I, in which the coxal ring is generally, if not always, incomplete dorsally (Fig. 107b). This is the situation in the adults of all genera except *Lassenia*, in which the two known species have both coxal rings I and II incomplete dorsally in the adult (Fig. 232). In all species of all genera of the Johnstonianidae, coxal rings III and IV are complete dorsally (Fig. 107a).

Urpore

The urpore is present in the larvae of all known species of Johnstonianidae and is well developed. There are no variants of known generic significance.

Lassenia Organ

This is a term which the author has applied to a structure of unknown nature and function immediately anterior to coxa III of larvae and adults of certain of the Johnstonianidae. It is especially well developed in *Lassenia lasseni* and *Lassenia scutellata* (Figs. 199, 209, 221, 251). A search of specimens of *Johnstoniana* and *Centrotrombidium* has failed to reveal a corresponding organ in these genera. At least a rudiment of this organ is found in larvae of *Diplothrombium monoense*, and *D. cascadense*, but not as yet in the adults of these species. A systematic search of other Parasitengona might reveal other groups in which this organ is found. It is most likely a gland of unknown function for in a number of specimens, both larva and adult, a duct leads from the body surface into the incompletely hydrolyzed remains of a glandlike mass of cells. Beyond this its nature is unknown.

Genital and Paragenital Sclerites of Adult

The Johnstonianidae are somewhat unusual among the Parasitengona in that the genital and paragenital sclerites are almost equally developed. Thus the genital opening is surrounded by four sclerites of very nearly equal size, and bearing roughly equal numbers of

setae. In fact, in *Diplothrombium micidium* the setae on the paragenital sclerites actually outnumber those on the genital sclerites proper. In the other terrestrial Parasitengona, the paragenital sclerites bear markedly fewer setae than the genital sclerites, if they bear any at all. There are invariably three pairs of genital acetabula in both the male and female. The penis of the male is relatively very small. A unique variant in the genital area is found in *Lassenia* in which there is a well developed pregenital tubercle. In *Lassenia lasseni* this makes its first appearance in the protonymph and increases in size in the deutonymph and adult. In *L. lasseni* it is a simple hemispherical tubercle, while in *L. spinifera* it is an elongate peduncle. In both cases it is heavily sclerotized and pigmented in the mature adult. Not even a rudiment of this pregenital tubercle has been found in the larvae, nymphs or adults of any of the other genera.

Anal Area

In all genera but *Lassenia* and *Polydiscia* the anal anlage of the larva is a simple slit with no associated setae. In both *Lassenia lasseni* and *L. scutellata* the slit is guarded by a pair of anal sclerites bearing two pairs of simple, smooth setae. The anal sclerites of the adults of all but *Johnstoniana* are distinctively crescentic in form, bearing in most cases a single row of smooth, simple setae (Figs. 18, 105, 240). In *Lassenia spinifera* there are two rows of setae on the anal sclerites, whereas in at least one male of *Lassenia lasseni*, the two anal sclerites had only 0 and 1 setae respectively. Perhaps the most significant variant is found in *Johnstoniana latiscuta* in which there are no anal sclerites at all (Fig. 68). There is a poorly defined anal area bearing a number of setae and differing from the surrounding cuticle only in the absence of striae.

Rostral Setae

The situation with regard to these setae cannot be finally resolved until further studies are made in other families. However, if we take *Lassenia lasseni* as a starting point, we find in the larva of that species three pairs of setae on the gnathosoma, all of these on the rostrum (Fig. 229). These will be called the proto-, deuto-, and tritorostral setae, and the presence of these three pairs is a condition characteristic of the larvae of many genera of the terrestrial Parasitengona. The protorostral setae are generally located dorsally or dorsolaterally on the tip of the rostrum, not only in this species but in the terrestrial Parasitengona in general. (These are the so-called "galeal setae" of specialists in the Trombiculidae. The writer prefers the term "protorostral setae" because it is simpler to give these three topographically related setae parallel names than to coin separate ones for each.) In *L. lasseni*, the deutorostral setae are under the margin of the velum in both the larva and the adult (Figs. 188, 229), while the tritorostral setae lie directly behind them. In *Centrotrombidium distans*, *Diplothrombium* and *Johnstoniana* there are only two pairs of setae in the larva (Figs. 45, 170, and 88). The distal pair of setae obviously are the protorostrals while the basal pair are either deutorostrals or tritorostrals. In larvae of *Centrotrombidium distans* (Fig. 45) a pair of very minute structures of uncertain nature is found along the margin of the velum in approximately the position occupied by the deutorostral setae of *Lassenia lasseni*. Apparently homologous structures are found in the adult as well (Figs. 2, 17). These may represent highly modified setae, or they may simply be points of insertion of muscles associated with the velum. Homologous structures have been found also in adults of *Diplothrombium monoense*, but neither in the adults nor the larvae of *Johnstoniana latiscuta*. From their position alone these would appear to be homologous with the deutorostral setae of *Lassenia* so that the series *Lassenia*—(*Centrotrombidium*, *Diplothrombium*)—*Johnstoniana* represents a progressive diminution in the size and importance of the deutorostral setae. This conclusion should be verified with studies in related genera and

families, but at present this appears to be the situation in the Johnstonianidae. In none of the larvae of the Johnstonianidae studied so far are there any setae behind the tritorostrals corresponding to the posterorostrals of some genera.

In the adults, of course, the base of the gnathosoma is generally covered with a considerably greater number of setae. An interesting exception is found in *Lassenia spinifera* (Fig. 248), in which only one pair of setae is added behind the tritorostrals; in *L. lasseni* (Fig. 180) many more setae are found here. In adults of *Centrotrombidium* (Fig. 17) the number of setae is apparently never great, but these are small species. The largest number of setae found behind the tritorostrals is in *Diplothrombium* and *Johnstoniana* (Figs. 125, 66).

It is difficult to say whether or not the setae found behind the tritorostrals are to be considered the ontogenic descendants of the tritorostral setae, but this does not appear to be the case, for the tritorostrals often retain a fairly characteristic appearance, differing rather markedly from the setae behind them (Figs. 23, 106). We would therefore have to consider these setae as having arisen *de novo* in the postlarval instars.

Velum

This structure appears to show few variants of any significance in the family. It is a simple structure of moderate size in all species studied by the writer.

Posterolateral Arms of Gnathosoma

Only moderate trends are noticeable within the family, with *Johnstoniana* and *Diplothrombium* having essentially no lateral arms on the posterior margin of the gnathosoma and with *Centrotrombidium* having only moderately developed arms here. The maximum development of these structures is found in *Lassenia*. Within this genus there is quite a bit of difference between the two known species, with *L. spinifera* having relatively longer posterolateral arms than *L. lasseni*.

Chelicerae

The form of the chelicerae in the Jonhstonianidae is fairly uniform, and is best seen in Figures 74 and 85. The tarsus or digitus mobilis is scythe-shaped with the dorsal margin ranging from nearly smooth to serrate (Fig. 7) to dentate (Fig. 247). The digitus fixus is membranous and shows no particular variants of generic importance. Perhaps the most significant variant in the form of the chelicerae is found in the tendency toward a downward flexure in the chelicerae of adults of the genus *Lassenia*. In *Lassenia lasseni* this flexure is only slightly developed, but in *L. spinifera* it is very pronounced (Figs. 200, 245). One very interesting bilateral anomaly was found in a single female of *Centrotrombidium distans* (Fig. 24) in which a typical seta and alveolus were found dorsally at the base of the digitus fixus. No other individuals of this species were found to have such a seta here, and certainly none of the other Johnstonianidae studied had a seta in this position, or anywhere on the chelicera. Such a seta is found at this point in many genera of *Eleutherengona*, however, and also in many of the Parasitiformes. The appearance of this seta in this anomalous individual not only suggests that the Johnstonianidae were derived from a group which did have a seta on the chelicera, but also raises the question why such a structure, apparently so irrevocably lost in the course of evolution of the group, should suddenly reappear as a bilateral variant in a single female of *Centrotrombidium distans*. Further details of this will be found under the description of the species.

Segmentation and General Form of the Palp

With a single exception the palpi of the Johnstonianidae are provided with five free segments. In larvae of *Lassenia lasseni* (Figs. 210, 213) there is a tendency toward the fusion of the femur and patella on the dorsal side;

this is not seen however in *L. scutellata* so that the character does not seem to have generic significance. In the adults the palpi are always distinctly five-segmented. The general form of the palpi in the adult is basically the same in all genera, slightly curved but essentially linear in dorsal view. The same is true of the larvae of all of the genera except *Lassenia*, in which the palpi are geniculate, owing to the expansion of the posterior or posterolateral aspect of the femur. Associated with this expansion of the femur, the trochanter is reduced to a narrow ring. The geniculate palpi of *Lassenia* larvae are suggestive of similar palpi which show up at other points within the terrestrial Parasitengona, and in these cases too it is interesting to note that the geniculate form is lost in the transition from larval to nymphal stages.

Fenestration of Trochanter of Palp

This is a characteristic which presently appears to be confined to the family Johnstonianidae. In the larva and adult of *Diplothrombium* and *Centrotrombidium* (Figs. 33, 61, 153, 179) there is a discrete oval window on the anterior (medial) aspect of the trochanter of the palp. This appears to be a portion of the cuticle which is considerably thinner and more transparent than the cuticle of the remainder of the trochanter. In *Johnstoniana* there is no trace of a fenestra. In *Lassenia* the situation is somewhat variable. In both of the known species the larva has a trochanter of very short length, probably associated with the geniculate form of the palp. In this there is no suggestion of a fenestra. In the adult of *L. lasseni* (Fig. 201) there is a well-developed fenestra, but the anterior margin is not closed off as it is in *Diplothrombium* and *Centrotrombidium*. Thus the trochanter has the appearance of being deeply incised on the anterior aspect. In *L. spinifera* (Fig. 239) the same condition is found, except that here the concavity is invaded by a distinct, although feeble extension of the cuticle of the femur.

The Palpal Tibia

The form of the tibia in the Johnstonianidae known to date is quite constant in the larva. In all species there is a heavy terminal seta which is unidentate in *Lassenia scutellata* and *Centrotrombidium distans*, but bidentate in the other four species for which larvae have been adequately described. The terminal setae have been given a number of names by workers in various divisions of the Parasitengona including "tibial claw, tibial spur," etc. While the name is not of paramount importance, it is well to keep in mind that this is not a claw, but nothing more nor less than a seta of unusual thickness, and it is preferable to refer to it as the terminal seta of the tibia. The term "claw" is a malapropism. In the larvae of all known species there are three normal setae behind the heavy spiniform terminal seta, and these may be either smooth or faintly pectinate.

In the adults of all known species, the terminal seta of the tibia is invariably unidentate. Moreover there is always a single subterminal spiniform seta which may be very close to the terminal seta as in *Lassenia* and *Diplothrombium micidium*, or may be removed from it by a distance greater than the diameter of the alveolus of the terminal seta as in *Johnstoniana* and *Diplothrombium monoense*. In *J. latiscuta* there is a heavy spine near the base of the subterminal spiniform seta. In some of the Trombidiidae there is also a *ctenidium* composed of several stout setae arranged in a regular series, but this structure is not present in any of the known Johnstonianidae.

Segmentation of the Legs of the Larvae

In both species of the genus *Lassenia* the femur is completely undivided so that there are only five free segments beyond the coxa. In *Johnstoniana latiscuta*, there is a distinct synarthrodial membrane on the ventral surface of the femur, but the dorsal sclerotized portion of the cuticle is continuous across the entire length of the femur (Figs. 87, 91, 93).

In both *Centrotrombidium* and *Diplothrombium* the basifemur and telofemur are completely separated by a flexible synarthrodial membrane. The femora of the adults of all species are divided.

Specialized Setae of the Appendages

Here it is well to digress a little in order to point out a difficult situation which exists in the nomenclature of the specialized setae of the appendages of the Parasitengona. In the United States the majority of the work in the terrestrial Parasitengona has been done in the Trombiculidae, by investigators whose major or even sole interest in the group was stimulated by the medical or general parasitological importance of these mites. In no case is there any published evidence that these workers have availed themselves of Grandjean's studies on the types of setae found on the appendages of mites in general including the Parasitengona. Grandjean's unexcelled contributions to the chaetotaxy of the Acari began in 1935 and have continued up to the present time. The major setal types were clearly elucidated and named prior to 1940. Grandjean's studies were cilmaxed in 1947 with the publication of his *Étude sur les Smarisidae* (1947) in which the broad outlines of the morphology of the various setal types on the appendages of the Parasitengona were laid down. This was one of the classics of modern acarology and it is incomprehensible that certain workers should have proposed a "standardized terminology" of the trombiculid mites, including the specialized setae, without a single reference to this or Grandjean's numerous other publications. It is to be hoped that acarologists generally will realize that it is definitely not in the best interest of acarology for any group of workers to set up a highly formalized and (by virtue of the number who have contributed) ostensibly authoritative system of terminology, either in complete ignorance or in complete disregard of the intensive work of others who have devoted many years of profound study to the morphology of the Acari. The Trombiculidae are no more than one very small segment of the Acari, and there is no reason why they should be treated differently from other groups, despite the medical importance of a few exceptional members of the family.

In his studies on the Johnstonianidae, the writer has followed the system of nomenclature proposed by Grandjean, first in 1935, and expanded in subsequent years. This will inevitably cause confusion to those familiar with only the terminology proposed by American workers (Wharton *et al.*, 1951). This is not done on the basis of priority, but with the knowledge that a choice must be made between two systems, plus the conviction, based on experience, that the older Grandjean nomenclature is more universally applicable, more fundamental, and, in the final analysis, more logical and comprehensible than the newer highly specialized terminology promulgated by investigators whose experience in the Acari is either primarily or entirely limited to immature stages in a single family.

The following table of equivalents is provided to help in the transposition from one system to the other.

Many examples could be cited to show the inevitable difficulties in the setal terminology which has sprung up during the past few years. One of these difficulties stems from the fact that the terminology has been evolved almost exclusively as an outgrowth of the describing of larvae and shows gross inconsistencies when an attempt is made to apply it to postlarval stages. A second is that related setae are often given quite different names, while some totally unrelated setae are given confusingly similar names.

For instance, the "subterminala" is a specialized seta found near the tip of the tarsus of leg I and the palp. In the adult the ontogenic descendants of the "subterminala" of the palpal tarsus are called "apical setae" or "apical nude setae." The morphological de-

Grandjean System, with Modifications Introduced in This Paper	*Terminology Proposed by Various Specialists in the Larval Trombiculidae*
solenidion$_1$ or s_1	spur of tarsus I
solenidion$_2$ or s_2	spur of tarsus II
solenidion$_3$ or s_3	microfemorala, microgenuala, microtibiala (in part)
solenidion$_4$ or s_4	microtibiala (in part)
solenidion of palpal tarsus	spur of palpal tarsus
dorsal eupathid of larval tarsi, or "eupathid at 0.71*d*" (etc.)	subterminala
distinventral eupathid of larval tarsi, or "eupathid at 0.92*pv*" (etc.)	pretarsala (a misnomer)
eupathidia of various segments of adult legs	(no acceptable equivalent)
companion seta of dorsal eupathid of larva	parasubterminala
companion seta of s_1 or s_2 of larva	(no equivalent)
companion seta of s_4 of larva	(no equivalent)
eupathidia of palpal tarsus of larva	subterminala of palpal tarsus of larva
eupathidia of palpal tarsus of adult	apical setae or apical nude setae
supracoxal setae	(no equivalent)
vestigial setae	microgenuala, microtibiala
famulus$_1$	microspur of tarsus I
famulus$_2$	microspur of tarsus II
bothridia	mastifemorala, mastitibiala, mastitarsala

scendants of the "subterminala" of the tarsi of the legs are simply called "nude setae" in the few cases in which they have been mentioned. "Nude setae" is apparently a catch-all category which includes famuli, solenidia, eupathidia, vestigial setae, and occasional normal setae which lack barbs. What is equally remarkable is that setae which are obviously morphological equivalents of the larval "subterminala" show up on segments as far back as the telofemur in adults. The term "subterminala" is therefore totally inappropriate to designate these setae, while the name "nude setae" is ambiguous. These are all eupathidia, and that term can be applied to these setae whether they are in larva or adult, on palp or leg, on tarsus, tibia, patella or telofemur. The "pretarsala" is another eupathid, but it is not on the pretarsus, and moreover its ontogenic counterparts in the adult are frequently indistinguishable from those of the "subterminala." The eupathidia are a particular type of seta found in a variety of places, and it seems unnecessary to apply special names to them.

The "genuala" and "tibiala" are both solenidia, and nearly all "tibiala" are structurally identical with all "genuala." Why, then, should these be given different names, just because they are on different segments of the legs? Why not also apply separate names to the normal setae found on the separate segments of the legs? It can also be pointed out that certain of the larval "tibiala" have counterparts which appear on the tarsus of the adult. The "spurs" are also solenidia, although differing structurally from the other solenidia of the legs. Giving the various types of solenidia different names, confusingly parallel in construction in some cases to the names of entirely different types of setae (femorala, genuala, tibiala, microtibiala, microgenuala, microtarsala, subterminala, pretarsala) complicates the picture unnecessarily. What is worse, it obscures the fundamental relationships and true differences between the setal types. These have been very adequately outlined by Grandjean, whose works are to be recommended most highly to any who have not yet read them.

During the course of the present studies it was found necessary to elaborate somewhat upon the solenidial classification in the Parasitengona. The Johnstonianidae, possibly more than any other family, show clearly the multiplicity of form of these setae, but at the

same time they also emphasize the essential unity of the various types. This will be more fully treated below.

The Solenidia of the Legs

The terrestrial Parasitengona are remarkable for the variety of solenidia developed on the legs. These must have considerable physiological, evolutionary and systematic significance, although it will require many years of work before these are understood. At the present time there are few unequivocal statements which can be made regarding the form and distribution of the various types, because of the complexity of study, and the lack of comparative studies in the several families. However, the most significant findings that have emerged from the present study are outlined here to provide at least a tentative beginning toward the eventual comprehensive understanding of the morphology of these important organs. In all cases the statements should be interpreted as applying most immediately to the Johnstonianidae, although exploratory studies in other families show clearly that their applicability extends far beyond the family momentarily under consideration.

1. The several types of solenidia are constant within a given genus. Interspecific variations are found in the numbers of a given type on specific segments of the legs, or differences in the position of certain highly characteristic types, or in minor but constant differences in form of a single type.

2. All species studied have at least three types of solenidia, while most have four. A decrease in number of types comes about through convergence of form rather than through deletion of one or another group of solenidia.

3. The different types of solenidia are recognizable in larval, nymphal and adult stages, although some apparent cases of divergence or convergence in form of two similar types have been observed in the transition from larva to adult.

4. As a general rule the solenidia of tarsi I and II of the larvae are different from each other and from the solenidia of the more proximal segments of the legs. Tarsus III does not possess solenidia in the larvae of the Johnstonianidae. Tarsi I and II in the larva always bear a single dorsal solenidion, usually without, rarely with a companion seta. The tarsal solenidia are thicker and more strongly marked with spiral or annular structure than those of the more proximal segments.

5. For purposes of convenience in differentiating the types and brevity in designating the types, the solenidia of tarsi I and II of the larvae and their ontogenic descendants in nymphs and adults, where these can be distinguished, will be designated solenidia$_1$ and solenidia$_2$, or s_1 and s_2 respectively. Where s_1 and s_2 cannot be differentiated this will be interpreted as a convergence in form so that s_1 and s_2 are indistinguishable. The reader should recognize that this is not the only interpretation that is available, but it should be equally apparent that if a different sequence of symbols is used each time a decrease in solenidial types is observed, the description of this change becomes unduly difficult. It is far simpler to utilize a single sequence of symbols which is applicable to the majority of cases and to fit observed exceptions to this rather than to evolve a new system to fit each particular variation. Further justification for this is found in the fact that the larvae of all species of Johnstonianidae studied so far, as well as all species of Trombidiidae and Trombiculidae which have been checked, have four types of solenidia on the legs which can be differentiated by either form or position, or usually both. The apparent reductions in solenidial types which have been observed to date consist entirely of convergences in setal types in the development from larva to adult.

6. The designation solenidion$_3$ or s_3 will be reserved for the type found on the proximal segments of the legs, with the exception of s_4 (see below). Even in cases in which s_1 and s_2 might be indistinguishable morphologic-

ally, so that they effectively comprise a single type, the designation s_3 will still be applied as indicated here, for the reason explained immediately above. Solenidia$_3$ are generally small, very slender, usually but not always lacking internal structure, and are probably invariably the most numerous type in both larval and postlarval stages.

7. In the larvae of all genera studied to date, a fourth type of solenidion is found dorsally on tibia I and will be designated solenidion$_4$ or s_4. This is a little larger than s_3 and typically shows some degree of internal structure. It may be intermediate in size to s_3 and s_1, and usually the distinction between these is considerably more difficult to appreciate in the adult than in the larva. The identification of s_4 is also confused by those cases in which a solenidion very similar to s_1 is found on tibia I in the position normally occupied by s_4. This is true of *Lassenia*, new genus, in which one distidorsal seta of tibia I has a companion seta and is of the same form as s_1. This might be interpreted either as a case in which s_1 is found on the tibia, or, as the writer has done, a case in which there is a strong convergence between s_1 and s_4. The situation is in no way simplified by the fact that throughout the protonymphal and deutonymphal instars of *Lassenia* there is a progressive diminution of this seta so that in the adult apparently only one type of solenidion can be found on tibia I with any degree of certainty—namely s_3.

8. As can be seen from the foregoing, the differences between solenidial types may be very marked, or there may be convergences which make interpretation of types exceedingly complex at times. However, we can only go so far in simplifying a complex situation, and perhaps the more surprising thing would be to find that all patterns of solenidial variation in the Johnstonianidae or the terrestrial Parasitengona in general could be smoothly fitted into a single scheme. If we fail to achieve this, we may yet succeed, if in failing we discover the reason for doing so.

The Johnstonianidae are a very fortunate group for studying the morphology of the solenidia, because in most genera the four types can be recognized not only in the larva but in the adult as well. This is especially so since s_2 in *Centrotrombidium*, *Diplothrombium*, and *Johnstoniana*, are of very unusual form and readily distinguishable from s_1 and s_4. In *Lassenia* larvae, s_1 and s_2 are of similar form and size, differing chiefly in the presence of a companion seta at the base of s_1. However, the companion seta is never retained in the postlarval instars, so this difference cannot be utilized in differentiating the two types of solenidia in the nymphs and adults. Consequently in this genus it is all but impossible to differentiate between s_1 and s_2 in the adult; moreover this situation extends to s_4 as well, as pointed out above.

One interesting feature of s_2 is that this type, while it appears first on tarsus II of the larva, is actually more abundant on tarsus I in the adult than it is on tarsus II. In other words they arise *de novo* on tarsus I in the postlarval stages, and in greater numbers there than in the site at which s_2 originally appeared in the larva. This is true in all genera (except possibly *Lassenia* in which the true state of affairs has not been ascertained because of the convergence in solenidial types in the postlarval stages).

The Eupathidia of the Legs of the Larva

Each of the four genera studied by the writer has a characteristic arrangement of the larval eupathidia. In all genera, the eupathidia are confined to the tarsi, and in all cases tarsus I has two eupathidia. Variations are found in the number of eupathidia on II and III, and in the presence or absence of companion setae. Both *Centrotrombidium* and *Johnstoniana* have eupathidial formulae of (2–1–0), but only in *Johnstoniana* is there a companion seta at the base of the dorsal eupathid. *Diplothrombium* has a formula of (2–1–0) in both species seen by the writer, but there is no companion seta with any of the eupathidia. In the two

species of *Lassenia* known in the larval stage, the eupathidial formula is (2–2–1), and the dorsal eupathid of both tarsi I and II in both species has a basal companion seta. Only in *Lassenia* is there a eupathid on tarsus III, and this is subterminal in position.

The Eupathidia of the Legs of the Adult

Here we find differences in the distribution of the eupathidia on the various segments of the legs, with *Centrotrombidium* having the eupathidia confined to the tarsi, and tarsus IV typically with only one eupathid. In the other three genera, eupathidia are found on all segments beyond the basifemur. In all genera but *Lassenia* there is a subterminal eupathid on tarsus IV. In *Centrotrombidium* this lies at about 0.85*a* to *av*, in *Diplothrombium* at 0.90 to 0.95*v* and in *Johnstoniana* at 0.91*pv*. Specific differences are found in the distribution of the eupathidia on the individual segments of the legs. One interesting example is found in the genus *Lassenia* in which ventral eupathidia are found on the telofemur, patella and tibia of leg I, whereas in *L. lasseni* all of the eupathidia are dorsal or marginal in position.

The Companion Setae

Companion setae are found only in the larvae of some genera, and are seemingly universally absent in the postlarval stages of all of the Parasitengona. Neither *Centrotrombidium* nor *Diplothrombium* has any companion setae in either larval or postlarval stages. *Johnstoniana* larvae have one companion seta associated with the dorsal eupathid of tarsus I, while in *Lassenia* there are four companion setae. These are associated with s_4 of tibia I, s_1 of tarsus I, and the dorsal eupathid of both tarsi I and II.

The Famulus

The famulus is the most constant of all the specialized setae in the Johnstonianidae. A famulus is present on both tarsi I and II in all genera, in both larval and adult stages. Variations in the position of the famulus often provide very useful specific characters (as in *Centrotrombidium*, for example), although a noticeable degree of variation in the position of the famulus is observed in some species. In others the famulus appears to show extremely little variation in position.

The Supracoxal Setae

The situation here is not certain, although it is probable that these are not as variable in their number and distribution as are the setae on the ventral surface of the coxa. Supracoxal setae, when present, are found both on the dorsal surface of the coxal portion of the gnathosoma, and on the dorsal surface of the coxae of leg I. This appears to be a general rule in the Parasitengona. In the Johnstonianidae, supracoxal setae are absent in all but the genus *Lassenia*. In the known species of this genus supracoxal setae are present on the dorsal surface of the gnathosoma as well as on the dorsal surface of coxa I. The distribution of supracoxal setae in the adult is always the same as in the larva so far as is known.

The Vestigial Setae

These are the small spikelike setae at the distidorsal end of the patella or tibia of legs I and II (Figs. 91, 194, 215). The distribution of these very often follows that of the supracoxal setae, that is, when the latter are present vestigial setae are also present. This is true in both *Centrotrombidium* and *Diplothrombium* in which none of the described species has either supracoxal or vestigial setae. In *Lassenia lasseni* and *L. spinifera*, vestigial setae are found on patella I and II and on tibia I; likewise supracoxal setae are present on the palpi and leg I. In *Johnstoniana latiscuta* an intermediate condition is found; for although there are no supracoxal setae, vestigial setae are present on patella I and II but are absent from all tibiae. As in the case of the supracoxal setae the distribution of the vestigial setae is identical in larva and adult in all species studied. The distribution of the supracoxal and vestigial

Distribution of Coxal, Supracoxal and Vestigial Setae (Larvae)

	No. Coxal Setae	Supracoxal Setae		Vestigial Setae			
		Palpi	I	I		II	
				pa	ti	pa	ti
J. latiscuta	2–1–1	0	0	1	0	1	0
D. monoense	2–1–1	0	0	0	0	0	0
D. cascadense	2–1–1	0	0	0	0	0	0
C. distans	2–1–1	0	0	0	0	0	0
L. lasseni	2–2–3	1	1	1	1	1	0
L. scutellata	2–1–2	1	1	1	1	1	0

setae in the larvae of the known Johnstonianidae is summarized in the table given above. Although this table is based on the larvae, the figures would be identical for the adults except for the number of coxal setae.

The Specialized Setae of the Palpal Tarsus of the Larva

One constant feature in the chaetotaxy of the palpal tarsus of the larva is the presence of a single solenidion on the posterior aspect of the basal one-third of the segment. The tarsal eupathidia exhibit one interesting variant. In both species of *Lassenia* these are of typical eupathidiform structure, tubular throughout, and relatively thin-walled. Moreover, the terminal eupathid is always at the very end of the segment (Fig. 253). In the other three genera, the end of the tarsus always extends beyond the insertion of the most distal seta. Moreover, none of the tarsal setae in larvae of these three genera are typically eupathidiform, although it may be presumed that some of the terminal ones are homologous with the typical eupathidia of *Lassenia*. These subterminal setae are strongly hemipectinate, and in *Centrotrombidium distans*, the one nearest the end of the segment is also flattened and expanded (Figs. 28, 29, 92, 176).

The Specialized Setae of the Palpal Tarsus of the Adult

While in the larva the solenidion on the posterior surface of the palpal tarsus is always in the basal one-half or one-third of the segment, in the adult there is a strong tendency for the solenidion to be displaced toward the distal end. In *Centrotrombidium* it is found at roughly 0.3*p*, in *Diplothrombium* at approximately 0.5*p*, and in *Johnstoniana* and *Lassenia* at approximately 0.8 to 0.9*p*. Paralleling the displacement of the solenidion is an increase in number of eupathidia. Thus, in *Centrotrombidium* there are only 2 terminal eupathidia, but in *Diplothrombium* there are 3 to 5, in *Johnstoniana* about 6, and in *Lassenia* from 6 to 15 depending upon the species and the individual. These trends are not entirely associated with size for although *Diplothrombium micidium* is smaller than *D. monoense*, the number of eupathidia on the tarsus of the palp is greater. Also the tarsus of the palp of *Johnstoniana latiscuta* is larger than that of *Lassenia spinifera*, yet there are only about half as many eupathidia.

DESCRIPTIONS AND KEYS

JOHNSTONIANIDAE new family

DIAGNOSIS: Adults with genital and paragenital sclerites about equally developed, and with three pairs of genital acetabula. Scutum with two pairs of typical sensilla, or with anterior pair greatly modified to absent. Scutum frequently with an anterior spine. Hysterosomal setae typically smooth, borne on individual sclerites. Chelicerae as in Trombidiidae, with base, movable tarsus, and a delicate dorsal membrane. Palpal tibia without ctenidium, with only the one terminal and one subterminal spiniform setae. Anterior wall of palpal trochanter often fenestrated.

Larvae also with one to two pairs of sensilla on the scutum. Dorsum with setae borne

individually on relatively large sclerites. Intercoxal area with a single pair of setae between III, or devoid of setae; urpore present. Either three or two pairs of rostral setae. Palpal tarsus simple, cylindrical or fusiform. Larvae self-detaching parasites of insects, living in damp to very wet places, and typically with relatively restricted temperature tolerances.

REMARKS: Not all of the variants of the morphological characters of the Parasitengona can be readily utilized in a key, but the more convenient ones are included here. It is interesting that the number of characters available in the larva considerably exceeds the number available in the adult. Actually the discrepancy is not as great as would appear at first glance, since some adult characters are omitted simply because of difficulties in interpreting them.

It appears possible that the Johnstonianidae as defined here will require further reorganization as more forms become known from other parts of the world. At present it is quite evident that there are two distinct groups of genera, the first including *Centrotrombidium*, *Diplothrombium*, *Johnstoniana*, and provisionally *Hirstithrombium* (Johnstonianinae Thor 1935). The second includes *Lassenia* new genus, *Polydiscia* Methlagl 1928, and provisionally *Crossothrombium* Womersley 1939 (*LASSENIINAE* new subfamily). The principal structural differences between the genera are summarized in the formula keys given below.

FORMULA KEY TO GENERA OF JOHNSTONIANIDAE
Based on Adults

1a. Anterior sensilla present, similar in form to the posterior sensilla, and at least one-half as long as the posterior sensilla (Figs. 70, 160).
1b. Anterior sensilla present, but considerably modified, less than one-half as long as the posterior sensilla (Figs. 183, 232).
1c. Anterior sensilla absent; scutum greatly reduced, bearing a single pair of sensilla, anterior to which is a single pair of normal setae (Fig. 4).
2a. Pregenital tubercle absent.
2b. Pregenital tubercle present (Figs. 185, 233).
3a. Anal sclerites present (Figs. 18, 105).
3b. Anus surrounded only by membranous cuticle containing setae, but no sclerites (Fig. 68).
4a. Palpal trochanter with anterior surface containing a distinct oval fenestra (Fig. 61).
4b. Distal margin of anterior wall of trochanter deeply incised, but the fenestra is not completely circumscribed (Fig. 201).
4c. Anterior wall of trochanter with no trace of a fenestra (Fig. 69).
5a. Eupathidia present on leg segments other than the tarsi.
5b. Eupathidia confined to the tarsi.
6a. Supracoxal setae absent from gnathosoma and coxae I.
6b. Supracoxal setae present on gnathosoma and coxa I.
7a. Vestigial setae absent from patella and tibia of all legs.
7b. Vestigial setae present only on patella I and II, absent from tibiae.
7c. Vestigial setae present on patella I and II, and tibia I; absent from tibia II.
8a. Solenidia$_2$ of tarsus I clavate, markedly different in form from s_1.
8b. Solenidia$_1$ and s_2 of tarsus I differing primarily in size; no sharp differences in form.

FORMULA KEY TO GENERA OF JOHNSTONIANIDAE
Based on Larvae

1a. Scutum with four pairs of setae (two pairs of normal setae plus two pairs of sensilla).
1b. Scutum with two pairs of setae (one pair of normal setae plus one pair of sensilla).

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	7	8	*JOHNSTONIANINAE*
a	a	b	c	a	a	b	a	**Johnstoniana**
a	a	a	a	a	a	a	a	**Diplothrombium**
c	a	a	a	b	a	a	a	**Centrotrombidium**
?	?	?	?	?	?	?	?	**Hirstithrombium**
								LASSENIINAE
b	b	a	b	a	b	c	b	**Lassenia**
?	?	?	?	?	?	?	?	**Polydiscia**
?	?	?	?	?	?	?	?	**Crossothrombium**

2a. Anal sclerites absent.

2b. Anal sclerites present, usually with one or more pairs of setae.

3a. Protorostral, deutorostral and tritorostral setae all present and setiform or spiniform (deutorostrals often concealed under velum).

3b. Deutorostral setae absent or reduced to extremely minute vestiges, tip of rostrum with only two pairs of setae.

4a. Palpal trochanter with anterior wall fenestrated.

4b. Anterior wall of palpal trochanter not fenestrated.

5a. Terminal seta of palpal tarsus eupathidiform (hollow, thin-walled, etc.).

5b. Terminal seta of palpal tarsus not typically eupathidiform, but flattened, strongly serrate, or otherwise modified.

6a. Tarsal eupathidia 2–1–0.

6b. Tarsal eupathidia 2–1–1.

6c. Tarsal eupathidia 2–2–1.

7a. Dorsal eupathid of tarsus I with companion seta.

7b. Dorsal eupathid of tarsus I without companion seta.

8a. Dorsal eupathid of tarsus II present, with companion seta.

8b. Dorsal eupathid of tarsus II absent.

9a. Solenidion$_4$ of tibia I with companion seta.

9b. Solenidion$_4$ of tibia I without companion seta.

10a. Coxal setae with formula 2–1–1.

b. Coxal setae with formula 2–1–2 or 2–2–3.

11a. Supracoxal setae absent on gnathosoma and coxae I.

b. Supracoxal setae present on gnathosoma and coxae I.

12a. Vestigial setae absent from patella and tibia of all legs.

b. Vestigial setae present on patella I and II only, absent from tibiae.

c. Vestigial setae present on patella I and II and tibia I; absent from tibia I.

13a. Femora I–III of all legs completely divided into basifemur and telofemur (six free segments beyond the coxae).

b. Femora I–III undivided (only five segments beyond the coxae).

c. Femora I-III partially divided, the synarthrodial membrane well formed ventrally, but absent dorsally (Figs. 87, 91, 93).

14a. Tarsi with two unequal claws on all legs, the anterior claw more erect than the posterior.

b. Tarsi with three claws on all legs, the anterior and posterior claws equal, the median (axial) claw more slender, erect.

15a. Intercoxal area with a pair of setae between III.

b. Intercoxal area without a pair of setae between III.

JOHNSTONIANINAE Thor 1935

DIAGNOSIS: Adults with either one or two pairs of sensilla on scutum. Pregenital tubercle absent. Solenidia$_2$ typically clavate, differing appreciably from s_1. Supracoxal setae absent from gnathosoma and coxa I in both larva and adult. Larvae without anal sclerites; usually with a single pair of setae in the inter-

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	*JOHNSTONIANINAE*
a	a	b	b	b	a	a	b	b	a	a	b	c	a	?	Johnstoniana
a	a	b	a	b	a	b	b	b	a	a	a	a	a	a	Diplothrombium
b	a	b	a	b	a	b	b	b	a	a	a	a	a	a	Centrotrombidium
?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	Hirstithrombium
															LASSENIINAE
a	b	a	b	a	c	a	a	a	b	b	c	b	b	b	Lassenia
a	b	?	?	a	?	?	?	?	b	?	?	a	b	b	Polydiscia
?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	Crossothrombium

coxal area between coxae III. Deutorostral setae absent; terminal seta of palpal tarsus not eupathidiform. Tarsi each with two claws.

Centrotrombidium Kramer 1896

ADULT: Length of idiosoma 500 to 1200 μ in known species. Scutum of both adult and larva bearing a single pair of clavate sensilla and anterior to these, a single pair of elongate normal setae; anterior sensilla absent. Anterior end of scutum drawn out into a long spine. Ocular plates bearing two refractile corneae each, or one refractile cornea and a non-refractile lobe. Dorsal hysterosomal setae borne on individual sclerites, no large plates present. Anal sclerites well developed. Supracoxal setae of legs and gnathosoma and vestigial setae of legs completely absent in both larva and adult. Trochanter of palp with anterior wall fenestrated in both larva and adult. Palpal tibia with a single subterminal spiniform seta; tarsus with one solenidion and usually only two eupathidia. Solenidia of legs of four recognizably different types; tarsi I and II with one or more clavate solenidia$_3$ on posterior aspect. Famulus of tarsi I and II located in distal one-fifth of segment, on posterior membrane of claw fossa. Eupathidia of legs confined to tarsi.

LARVA: In addition to those which are common to both larva and adult, the larva has the following characteristics. Ocular plates distinctly bicorneate. Anal sclerites absent. Velum small, simple; deutorostral setae absent, or represented by vestigial structures. Base of gnathosoma without posterorostral setae. Femur of all legs divided. A single clavate solenidion$_2$ on tarsus II, s_1 of tarsus I curved, rodlike. Tarsus of all legs with two simple, smooth claws.

REMARKS: At present only five or six species are known, including the three new ones described here. *C. schneideri* Kramer 1896 is rather widely distributed in Europe, and *C. australasiae* is known from Australia. *C. misellum* (Berlese), from Mexico, is provisionally placed in this genus. The genus is probably cosmopolitan. The adults are small, brown mites, rather inconspicuous, found crawling over wet ground along the margins of streams and ponds. The writer has also collected them in estuarine habitats. The larvae are probably parasitic upon various small arthropods but nothing is known about host relationships. The known species can be separated on the basis of the diagnostic formulae given below.

FORMULA KEY TO ADULTS OF CENTROTROMBIDIUM

1a. Sensilla of scutum with distal portion nearly spherical, length of stalk less than twice the diameter of the sphere, and less than the distance between the sensillar alveoli.

1b. Distal portion of sensillum clavate or pyriform, stalk very long, at least twice as long as the expanded tip, and considerably longer than the distance between the alveoli.

1c. Sensilla not swollen, but slender throughout.

2a. Dorsal hysterosomal setae relatively long-slender, tapering uniformly to a very fine point (Figs. 19, 22).

2b. Dorsal hysterosomal setae appreciably stouter and of more nearly uniform diameter throughout, reaching only a little beyond the margin of the setigerous sclerites (Fig. 64).
3a. Ocular plates with only one distinct cornea, plus a non-refractile posterior lobe (Fig. 53).
3b. Ocular plates with two distinct corneae.
4a. Tarsus I with only two (exceptionally 1 or 3) clavate solenidia$_3$ on posterior membrane of claw fossa (Fig. 48).
4b. Tarsus I typically with more than two clavate solenidia here.
5a. Famulus of tarsus II very close to alveolus of clavate solenidion$_3$, removed from it by a distance no greater than the length of the solenidion, and with no other setal alveoli in the intervening distance (Fig. 49).
5b. Famulus of tarsus II removed from alveolus of clavate solenidion$_3$ by a distance greater than the length of the solenidion; one or two normal setae in intervening distance (Figs. 6, 8).
6. Range in idiosomal length, by sex, where known.

Since the larva of only *C. distans* is known, no key to larvae can be given. The above key does not include all the characters of probable specific value in the genus, but they are the more important ones. Others include the difference in form of the posterior end of the scutum, which is important in differentiating *C. distans* and *C. approximatum*, but this is difficult to state in words. Womersley (1942, p. 171, fig. 2c) showed no anterior spine on the scutum of *C. australasiae* Womersley 1942. It is likely that this was drawn from an undissected specimen, and in such specimens the scutal spine often projects straight downward so that it cannot be seen in dorsal view. Whether or not this is the case in Womersley's species is not known, but the possibility should certainly be kept in mind upon comparing this with other species of the genus.

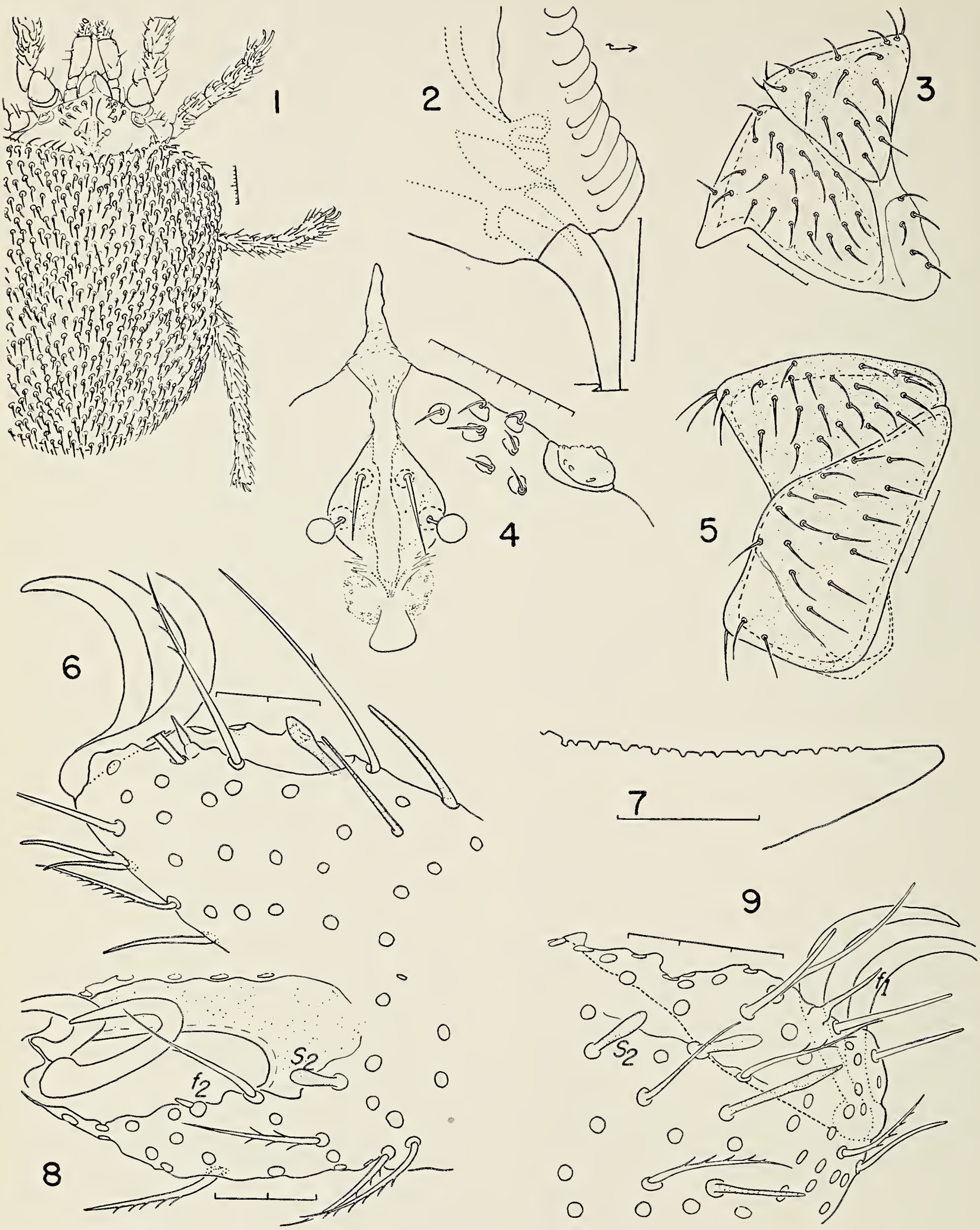
Centrotrombidium distans new species

FEMALE: Idiosoma (Fig. 1) 897–988 μ long, 702–728 μ wide (two ovigerous specimens). Scutum (Fig. 4) drawn out into a long anterior spine, and with a single pair of capitate sensilla, anterior to which is a pair of stout, long, smooth to faintly roughened setae; anterior sensilla absent. Crista metopica extending for most of length of scutum. Ocular plates very small, bearing only one prominent cornea (the anterior one) and an angular process (Fig. 25). Cuticle of ocular plate outside of cornea minutely tuberculate. Propodosoma between ocular plate and scutum with about seven setae, all of which lie at or anterior to the level of the sensilla. Dorsal and lateral body setae (Fig. 19) arising from alveoli borne on prominent raised sclerites, shaft sharply deflexed near base of seta. Membranous cuticle between sclerites with no visible markings except for a few faint parallel striae seen in some parts of the body. Subcuticular reticular layer a network of fine fibrils.

Coxae I and II (Fig. 3) with only about 20 to 25 smooth setae each; pars medialis coxae with about 5 setae; supracoxal seta absent. One small apodeme behind coxa II, very feebly developed. Coxae III and IV also with about 20 to 25 setae (Fig. 5). Ventral body setae like those of dorsal and lateral surfaces. Genital sclerites (Fig. 10) with 9 to 12 smooth

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	
a	a	a	a	b	♀ 897– 988 μ	*distans* n. sp.
a	a	a	a	a	♀ 988–1092 μ	*approximatum* n. sp.
a	a	a*b*	a	b	♀ 962 μ	*hadroseta* n. sp.
a	a	b	?	?	525 μ	schneideri Kramer 1896
c	b?	?	?	?	800 μ	misellum (Berl.) 1918
b	?	b	b?	?	1020 μ	australasiae Wom. 1942



FIGS. 1 – 9. *Centrotrombidium distans* n. sp.: 1, dorsum, female; 2, tip of rostrum showing tritorostral seta and presumed deutorostral rudiment; 3, coxae I and II, female; 4, propodosoma, female; 5, coxae III and IV, female; 6, tarsus I, female, posterior; 7, cheliceral tarsus, female; 8, tarsus II, male, posterodorsal; 9, tarsus I, posterior. female.

setae in a single row, paragenital sclerites with 15 to 18 smooth setae. Three pairs of genital acetabula. Anus (Fig. 18) flanked by two crescentic sclerites bearing 6 to 8 smooth setae each. Base of gnathosoma and rostrum as described for *C. approximatum*, new species. Chelicerae also as in the following species, except that the teeth on the chelicerae appear to be significantly heavier (compare Figs. 7, 52). In the holotype female there was a seta at the base of the dorsal membrane of one chelicera, and an indication of at least the alveolus and a short shaft on the other chelicera (Fig. 24). However, no such seta could be found on the male collected at the same locality, nor on either the male or female of *C. approximatum*. This is an interesting anomaly, suggestive of the condition normally found in the Parasitiformes, and many of the Eleutherengona in which a seta is frequently found in this position in normal individuals. Number, form, and arrangement of setae on all segments of the palp identical with that of the holotype of *C. approximatum* (Figs. 58, 59, 61).

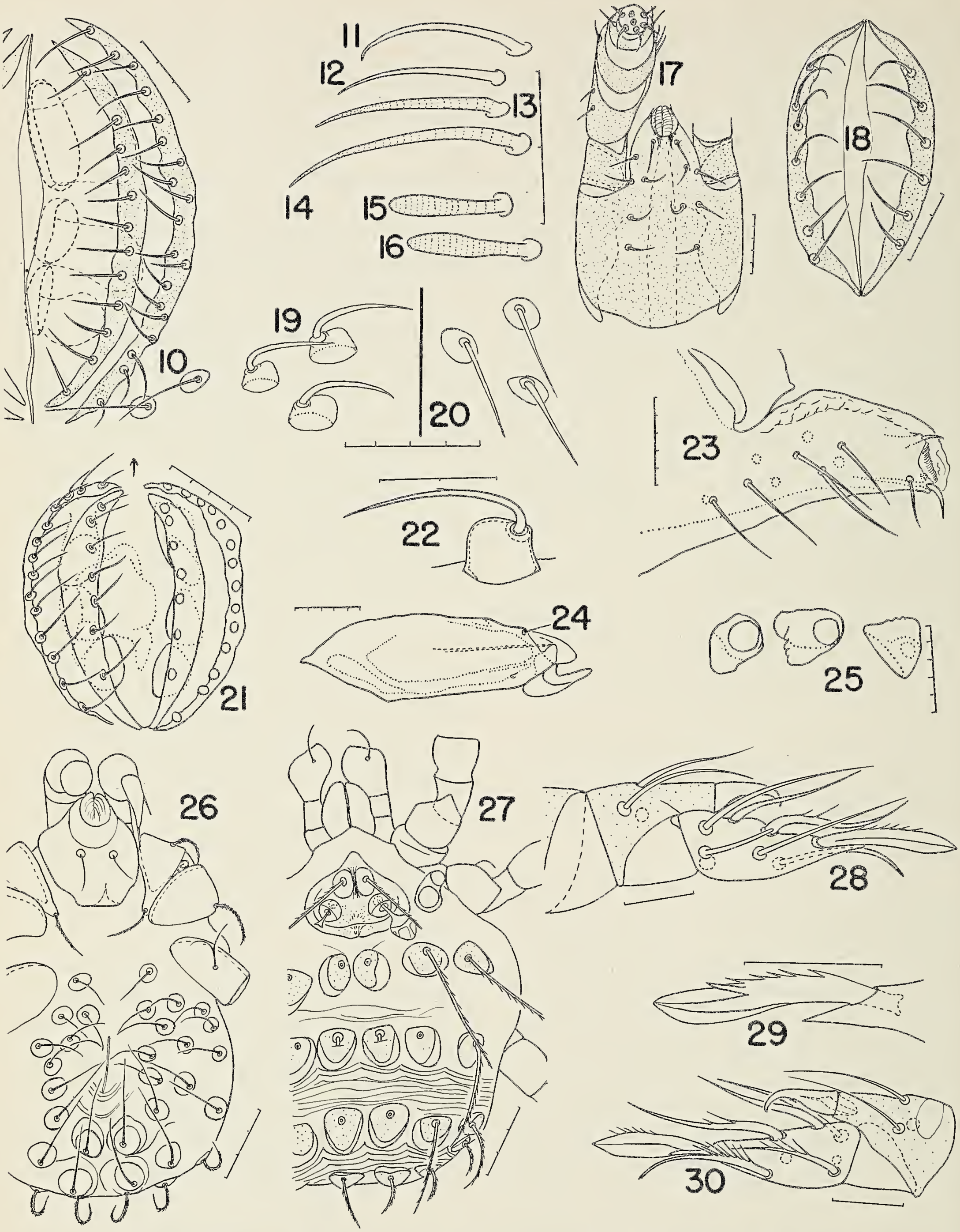
Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Vestigial setae absent on all segments of all legs, and eupathidia present only on the tarsi. Tarsus I greatly swollen, height/length 0.50 to 0.56 (two specimens), claw fossa beginning at 0.64 to 0.65 and extending to end of tarsus. Typically with two clavate solenidia$_2$ on the posterior aspect of tarsus I, the first of these at about 0.65 to 0.68*p*, the second at 0.70 to 0.79*p* (Fig. 9). In some cases s_2 have a faintly annulate structure; in others they appear smooth. The peculiar seta with the fusiform distal half seen disti-ventrally to the solenidia$_2$ in Figure 9 is an anomaly. Famulus spikelike, located at 0.90 to 0.93*pd*, arising from a distinctly vesicular alveolus. Tarsus I also with numerous s_1 and eupathidia, the latter extending around the ventral and distal margin of the tarsus from 0.43*v* to 0.80*d*. The eupathidia have a characteristically geniculate terminal filament visible under oil (not shown in figure). Some tarsi I have only one or as many as three solenidia$_2$, but two is the normal number. Tarsus II with a single clavate solenidion$_2$ near the basal end of the claw fossa (Figs. 6, 8) at about 0.64*pd*, and a peglike famulus at 0.85*pd*, borne on a distinctly vesicular alveolus. Tarsi III and IV with two and one eupathidia each in the material studied. S_2 highly distinctive (Figs. 15, 16), but s_4 (Fig. 13) occasionally intergrading with s_1 and s_3 so that it is difficult to assign certain setae to one or another type.

MALE: Body 754 to 858 μ long (average 806 μ, three specimens). In general resembling female except for structure of genital area (Fig. 21). Genital sclerites with 6 to 9 setae in a single row, paragenital sclerites with 12 to 18 setae in a single row. Three pairs of genital acetabula. An interior circlet of about 12 setae can be seen in some favorable specimens, but are not shown in the figure. Penis very small, inconspicuous. Anal sclerites as in female.

LARVA: Idiosoma (Fig. 27) 152–167 μ long. Scutum somewhat triangular, greatly reduced (Fig. 32), bearing only the posterior pair of sensilla, anterior to which is a pair of stiff, hemipectinate setae. Between the latter a very short, rudimentary crista metopica. Sensilla capitate, the spherical distal portion crumpled in some mounted specimens (artifact). Ocular

	tr	bf	tf	pa		ti		ta					
	n	n	s_3	s_3	s_4	s_3	s_4	s_1	s_2	s_3	s_4	e	f
I	4–5	15	6–10	31	2–3	28–35	3	15	2	0	4?	m	1
II	4	11	3–7	16	0	17	2	6–8	1	0	0	2	1
III	5	11	3–4	8–12	0	10–14	0	0	0	0	2	2	0
IV	8	9	4	9	0	8	0	0	0	0	1	1	0



FIGS. 10–30. *Centrotrombidium distans* n. sp.: 10, genital opening, female; 11, solenidion$_3$, patella I; 12, s_3, femur II; 13, s_4, tarsus II; 14, s_1, tarsus I; 15, s_2, tarsus I; 16, s_2, tarsus II (all from female); 17, gnathosoma, female; 18, anus, female; 19, dorsal hysterosomal setae, side view; 20, same, top view; 21, genital area, male; 22, marginal body seta, female; 23, rostrum, female, lateral; 24, chelicera showing abnormal seta, female; 25, ocular plates, female, various aspects; 26, venter, larva; 27, dorsum, larva; 28, palpal tibia and tarsus, larva, posterior; 29, terminal seta of palpal tarsus, larva; 30, tibia and tarsus of palp, larva, anterior.

plates bicorneate, simple in form. Dorsal and marginal setae numbering 24 in four rows of 6 each, each seta hemipectinate and borne on a separate sclerite.

Coxa I with one pectinate seta laterally and another in the medial angle (Fig. 26); supracoxal seta absent. Medial portion of coxa I very indistinct, differentiated only by the absence of striae. Coxa III with a single bifurcate seta. Intercoxal area with a single pair of smooth setae, inserted on a pair of smooth, slender sclerites between III. Fifteen postcoxal setae on each side, borne on individual sclerites surrounding the anus.

Base of gnathosoma (Fig. 45) with one pair of simple smooth setae (tritorostrals?), deutorostral setae vestigial, visible only under oil immersion; protorostrals small, simple. Velum oval in outline, reticular in appearance. Chelicerae small, compact (Fig. 44), digitus fixus very small, pointed, tarsus not in favorable position for study, but apparently with one dorsal tooth proximal to the tip. Palpi (Fig. 33) five-segmented, trochanter lacking setae, femur and patella each with a single dorsal seta with a few barbs. Palpal tibia with three simple setae and the unidentate spurlike seta which is inserted in the end of a truncate projection of the tibia. Palpal tarsus (Figs. 28, 30) with solenidion at 0.10*p*, with only the faintest indication of annuli. A curved, hemipectinate seta at 0.50*av* which extends along ventral margin of tarsus, somewhat obscuring the very fine tip. A very heavy seta at 0.71*d*, terminal portion flattened, spatulate, the margin pectinate. Tip of tarsus forming a sharp pointed spine extending well beyond insertion of spatulate seta. Otherwise with five setae which are smooth, or which bear from one to four pectinations; typical eupathidia absent.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Tibia I with one s_3 and one s_4 dorsally, II and III each with one s_3, and with a ventral keel which is best developed on III. The solenidia on the first five segments of the legs have no perceptible spiral structure.

Tarsus I (Fig. 31) with s_1 at 0.47*pd*, a smooth eupathid at 0.75*pd*, and a heavy, smooth eupathid at 0.87*v*. A smooth normal seta at 0.80*d*. Otherwise with 25 hemipectinate normal setae. Claws as described for II. Tarsus II (Figs. 34, 35) with a spikelike famulus at 0.68*pd*, and a clavate solenidion$_2$ at 0.67*d*, the stalk sometimes showing distinct spiral structure. A long, smooth, normal seta at 0.81*d* and a eupathid at 0.80*pv*, otherwise with 21 hemipectinate normal setae. Claws two in number, the anterior one smoothly curved, scythe shaped, the posterior one with similar taper and thickness, but with a sharp 90 degree flexure between basal and middle thirds. Tarsus III (Fig. 46) with a smooth normal seta at 0.65*d*; otherwise with 14 normal hemipectinate setae. Tarsal claw as on I and II.

TYPE LOCALITY: Tule Lake, Siskiyou County, California (holotype female). Common along alkali-encrusted shore of lake, on mud overgrown with grasses and other plants. Types in author's collection.

REMARKS: This species is widely distributed throughout the western United States, living in marshy situations. It has also been collected at a point about 4 miles north of Tonasket, Okanogan County, Washington, on the borders of small ponds on the Okanogan River. These ponds are permanent, and are usually flooded each year. A second species, *C. ap-*

	tr	bf	tf		pa		ti			ta				
	n	n	s_3	n	s_3	n	s_3	s_4	n	s_1	s_2	e	f	n
I	1	1	1	5	4	5	1	1	4	1	0	2	1	26
II	1	2	1	4	2	4	1	0	4	0	1	1	1	22
III	1	2	1	4	2	4	1	0	4	0	0	0	0	15

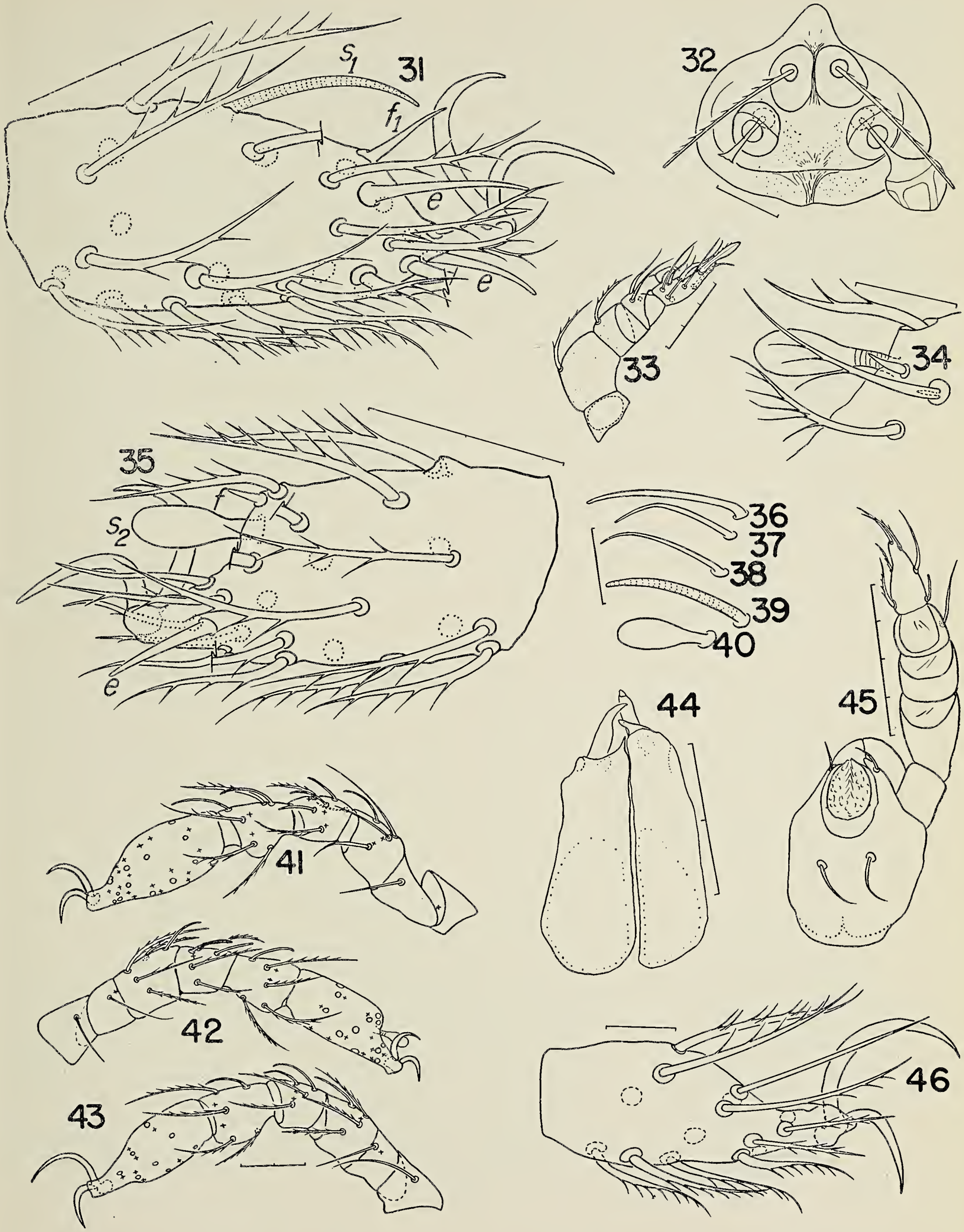
proximatum n. sp. was found at the latter locality. This is very similar to *C. distans* but differs in at least three consistent respects. Because of the high degree of variation found in the Johnstonianidae and the terrestrial Parasitengona in general, it is often difficult to assess the significance of small variations between individuals. However, all individuals of *Centrotrombidium* seen by the writer fall into one of two groups depending upon the degree of separation between the clavate solenidion$_2$ and the famulus on tarsus II (Figs. 6, 49). In both males and females of *C. distans* these are widely separated as described above; whereas in the others the clavate solenidion and famulus are very close together. Moreover, the famulus in *C. distans* is borne on a protruding vesicular base while that of the other form arises from an alveolus which is set at or below the general surface of the cuticle. The second arrangement has been found in both males and females so that sexual differences are not involved. A second difference is in the number of solenidia on the dorsal surface of tibia I. These segments are approximately the same size in the two forms, but in *C. distans* there are approximately 34 to 41 solenidia; whereas in the second form there are only about 20. A third difference, in the form of the scutum, is discussed in the description of *C. approximatum*.

Centrotrombidium approximatum new species

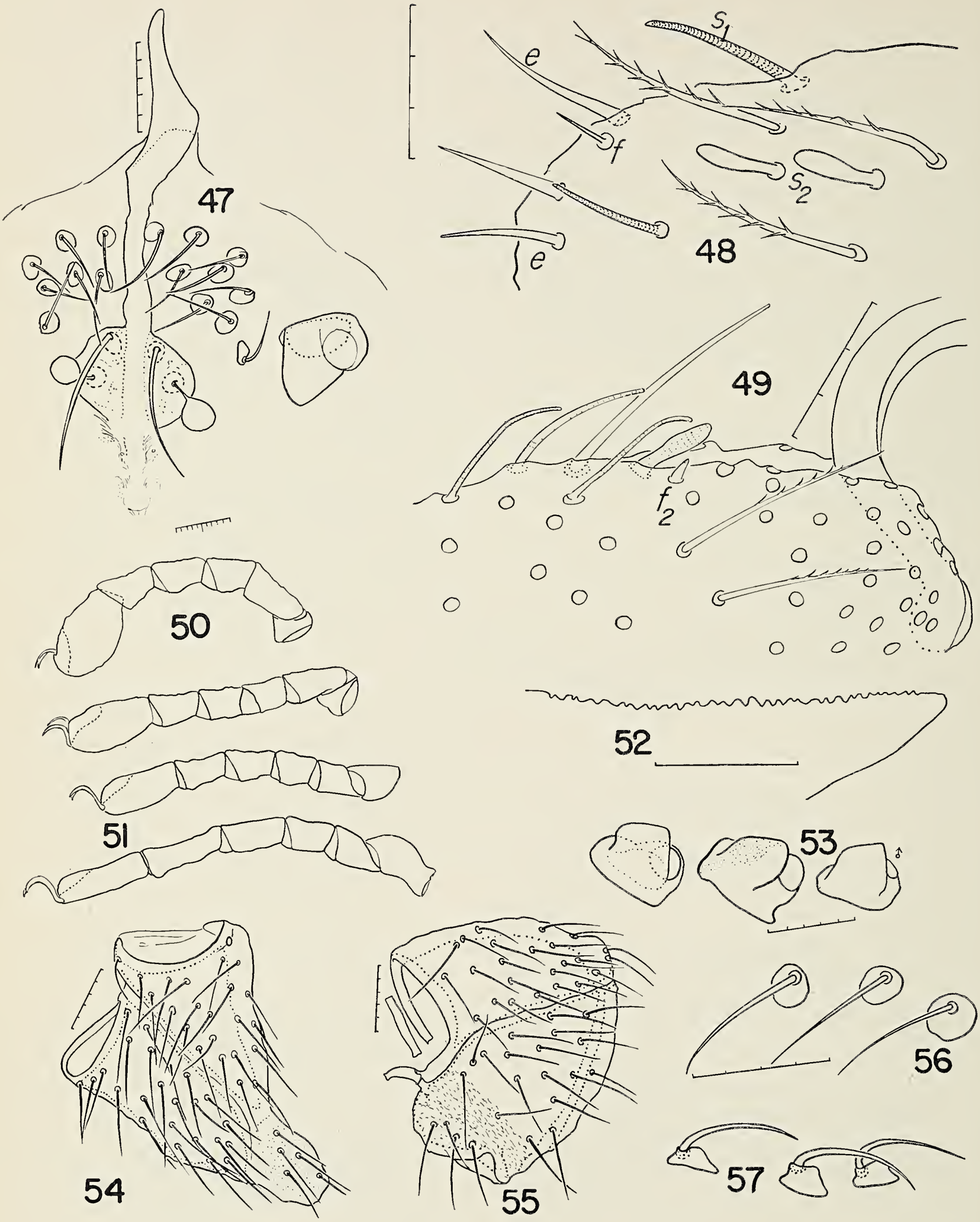
FEMALE: Very similar to *Centrotrombidium distans* new species in size and general appearance. Length 988 to 1092 μ to tip of scutal spine, width 728 to 884 μ, length/width 1.23 to 1.35; average 1050 μ long, 801 μ wide, length/width 1.31 (five ovigerous females). Scutum slightly larger than in *C. distans*, with the portion behind the area sensilligera of nearly uniform width throughout in contrast with the expanded form of this part in *C. distans*. Crista metopica well developed, the portion between the area sensilligera and the scutal spine being somewhat longer generally than in *C. distans*, but this is a variable feature. Posterior sensilla spherical distally, anterior sensilla absent; scutum with only one pair of setae in addition to the sensilla. With 2 to 8 setae between the scutum and each ocular plate (average 4.5 setae, six specimens). Ocular plates appreciably larger than in *C. distans* (Fig. 53) bearing a single cornea laterally and a large lobe medially. The medial lobe is punctate like the rest of the ocular plate, and apparently is never tuberculate as it frequently is in *C. distans*. Dorsal and marginal body setae apparently slightly longer than in *C. distans*, each borne on a separate sclerite, but these sclerites are more nearly hemispherical, and noticeably less elevated than in the preceding species (Fig. 57). Membranous cuticle of dorsum smooth, subcutaneous reticular layer as in *C. distans*.

Coxae I and II with 27 and 26 smooth, slender setae each, pars medialis coxae with 5 setae (one specimen). Coxal ring I incomplete dorsally, supracoxal setae absent; coxal ring II complete. Both I and II with a large articulating process in anterior portion of coxal ring (Fig. 54). Intercoxal area of I and II with 9 to 20 smooth, simple setae, each borne on an individual sclerite; no apodemes behind II. Coxae III and IV with 27 and 25 smooth slender setae respectively in specimen counted, coxal rings complete dorsally; also with a prominent articular process on the anterior half of the coxal ring. Genital and paragenital sclerites as in *C. distans* (Fig. 10), genital sclerites with a single row of 9 to 11 setae, paragenital sclerites with a single to double row of 12 to 17 setae. Three pairs of genital acetabula. Anal sclerites also as in *C. distans*, with 6 to 10 setae on each side.

Base of gnathosoma essentially as in *C. distans* but with a larger number of setae (6 to 10). Velum directed anteriorly, protorostral setae of same form as in *C. distans;* a pair of ventrally directed setae distiventrally on rostrum as in the case of *C. distans*. It appears probable that these are the tritorostral setae, for between these and the protorostrals is a



FIGS. 31–46. *Centrotrombidium distans* n. sp., larva: 31, tarsus I; 32, scutum (sensillum crumpled); 33, palp, posterior; 34, famulus and solenidion$_2$, tarsus II; 35, tarsus II; 36, solenidion$_4$, tibia I; 37, s_3, patella III; 38, s_3, femur III; 39, s_1, tarsus I; 40, s_2, tarsus II; 41, leg I; 42, leg II; 43, leg III; 44, chelicerae, dorsal; 45, gnathosoma, ventral; 46, tarsus III.



FIGS. 47–57. *Centrotrombidium approximatum* n. sp.: 47, propodosoma, male; 48, tarsus I, female, posterior; 49, tarsus II, male, posterior; 50, legs I and II; 51, legs III and IV, female; 52, cheliceral tarsus, female; 53, ocular plates, female to left, male to right; 54, coxae I and II, female; 55, coxae III and IV, female; 56, hysterosomal setae, female, from above; 57, hysterosomal setae, side view.

pair of minute structures like those found in *C. distans* which may represent the vestiges of the deutorostral setae. Including the protorostrals and tritorostrals the rostrum bears 10 to 16 setae. Chelicerae (Fig. 60) of standard form, tarsus heavily sclerotized, appearing smooth at low magnification but with 20 to 30 extremely minute teeth visible at magnifications of 250 x or higher. Trochanter of palp (Fig. 61) with fenestral membrane on anterior aspect, setae absent; femur with about 12 smooth straight slender setae. Two of the normal setae on the femur of the palp appear to occupy a characteristic posterior position, isolated from the remaining 10 setae of the segment. Patella with about 9 setae, tibia with 8 smooth slender setae plus the large clawlike unidentate distal seta, and a shorter spiniform seta near its base. Tarsus of palp with three rather heavy normal setae along dorsal margin (Figs. 58, 59), two heavy eupathids distally, and a single solenidion posteriorly.

MALE: Resembling female in all essential respects noted above except for structure of genital area. Genital sclerites and paragenital sclerites as in female, but with slightly fewer setae in most cases. Penis of rather characteristic form, with three elongate apodemes. Genital acetabula numbering three pairs. Anal sclerites also as in female.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Basifemur I with about 20 to 25 normal setae. Vestigial setae absent; eupathidia found only on the tarsi. Tarsus I with famulus at 0.89*pd* and with two solenidia$_2$ on posterior aspect (only one in some cases). Tarsus II with s_2 at about 0.64*pd*, and with a spikelike famulus at 0.64 to 0.73*pd*. Eupathidia extending from 0.55*v* to 0.95*d*. Eupathidia of tarsus I extending from 0.49*v* to 0.85*d*. Tarsus I also with numerous s_1 and a number of smaller solenidia intermediate in size and form between s_1 and s_3, and assigned in the table to type s_4. There appears to be fairly complete intergradation between s_4 and s_1 as in the case of *C. distans*.

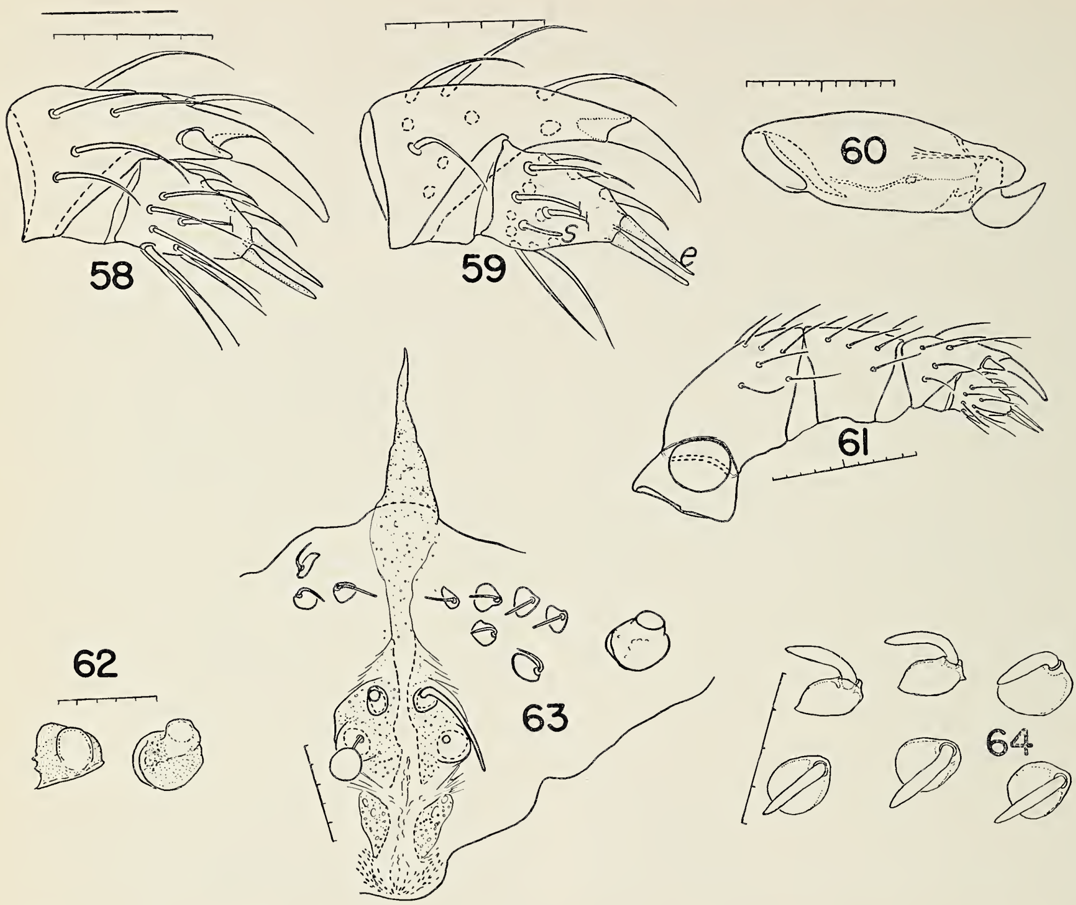
TYPE LOCALITY: About 4 miles north of Tonasket, Okanogan County, Washington, from border of small permanent pond. August 14, 1952. Collected by the writer. This species has not been found elsewhere, and may be a more northerly form, whose principal range extends into British Columbia.

REMARKS: This species is very similar to *Centrotrombidium distans* new species, but differs consistently in the close approximation of s_2 and the famulus of tarsus II (hence the specific name). It also differs in having considerably fewer solenidia on the legs (approximately 125 compared with 200 in *C. distans*). The difference is largely due to the discrepancy in the number of s_3 (about 80 in *C. approximatum*, compared with 160 in *C. distans*); the other solenidial types are present in approximately equal numbers in the two species. Other differences are in the form of the posterior end of the scutum, and the form of the ocular plate as indicated in the foregoing description.

Centrotrombidium hadroseta new species

FEMALE: A single specimen of this form was found at the type locality of *C. approximatum*. It is closely related to *C. distans* from which it differs in only very minor respects. Body of same form as *C. distans*, 962 μ long, 650 μ wide, length/width 1.48. Scutum (Fig. 63) essentially as in *C. distans*, except that the setae in front of the sensilla appear to be

	tr	bf	tf	pa		ti		ta					
	n	n	s_3	s_3	s_4	s_3	s_4	s_1	s_2	s_3	s_4	e	f
I	4–5	23	11	31	2–3	7–9	1	11	2,*1*	0	7	m	1
II	4–5	15–16	6	10	1	6	1	11	1	0	0	m	1
III	6	11–13	4	8	2	4	1	0	0	2	3	8	0
IV	12	9–10	4	6	0	4–5	0	0	0	1	1,2	1,0	0



FIGS. 58–61. *Centrotrombidium approximatum* n. sp.: 58, tibia and tarsus of palp, female, anterior; 59, tibia and tarsus of palp, female, posterior; 60, chelicera, female; 61, entire palp, female, anterior.

FIGS. 62–64. *Centrotrombidium hadroseta* n. sp., female: 62, ocular plates, anterior aspect on left, dorsal aspect on right; 63, propodosoma; 64, hysterosomal setae, side and top view.

somewhat shorter. Sensilla with terminal portion spherical, rather abruptly differentiated from stalk as in *C. distans*. Ocular plates (Fig. 62) with a single hyaline cornea plus a large punctate posterior lobe bearing a few tubercles. Dorsal body setae borne on individual sclerites as in other members of the genus, the sclerites in the form of very low cylinders, relatively lower than those of *C. distans;* shaft of setae short, extending only a little beyond the margin of the setigerous sclerite, appreciably thicker than in *C. distans*, and not tapering uniformly as in that species (hence the name). Other details of dorsum and venter essentially as in *C. distans*. Genital sclerites with 7 and 8 setae each, paragenital sclerites with 15 and 16 setae each. Anal sclerites each with 7 setae. In the holotype female, the solenidion of the tarsus of the palp is located somewhat more distally than in the previously described species, and the terminal eupathidia of the tarsus are somewhat longer; however, it is impossible at present to know whether these differences are of real significance.

The material available is not suitable for counts of the setal types. In general the chaetotaxy appears to resemble that of *C. distans* very closely. Tarsus I bears either 2 or 3 clavate solenidia$_2$, with the normal two being located at 0.67 and 0.74*p* in the specimen studied. One of the tarsi I of the holotype has a third s_3 at 0.52 *pd*. Eupathidia of tarsi I extending from 0.34*v* to 0.83*pd*. Famulus elongate, straight, its alveolus at 0.88*pd*. Claw fossa extending from 0.72*d* to end of tarsus. Tarsus II with a clavate s_2 at 0.61*pd* and a spikelike famulus at 0.81*pd*. These positions correspond almost precisely with the positions of the same setae in the holotype of *C. distans*, but the famulus appears to have a normally recessed alveolus, and not a vesicular one as in *C. distans*.

TYPE LOCALITY: About 4 miles north of Tonasket, Washington, on border of a small permanent pond (holotype female). August 14, 1952, collected by the writer. This is also the type locality of *C. approximatum* new species. Type in author's collection.

REMARKS: The type locality of this species is the only point at which more than one species of *Centrotrombidium* has been observed by the writer, all three forms newly described in this paper having been found here. The differences between *C. distans* and *C. hadroseta* cannot be fully evaluated at present because of lack of sufficient specimens of the latter species. However, 50 specimens of both sexes of *C. distans* have been seen by the writer, and there is no indication of convergence in setal type between any of these specimens and the type of *C. hadroseta*. While it is possible that further study will change this, the most probable explanation at present appears to be that we have here two sibling species.

Centrotrombidium misellum (Berlese) 1918, new combination

This was originally described as *Diplothrombidium misellum* Berl. (*sic*). A translation of Berlese's description is given above.

395. *Diplothrombidium misellum* Berl. n. sp. Dark red, small. Abdomen subquadrate–rounded, very slightly excavated in lateral margin, front truncate, well-armed posteriorly. Crista metopica with a single area sensilligera, anterior and posterior sensilla very close together; anterior sensilla spiniform, moderately swollen, posterior sensilla long, very slender. Body completely clothed with hemispherical papillae, setae short arcuate, directed posteriorly. Legs very short, anterior ones shorter than body, tarsus broad, ovate, little longer than broad (140 μ long, 80 μ broad), tibia three times narrower than the tarsus. Palpi rather large, barely swollen, unguiculate, provided with a stout spine at the base of the main claw three times shorter than the claw. Papilla, (tarsus?) conical, short, apex armed with three spiniform setae, 30 μ long, cuticle of legs, rough, warty, covered with simple short setae. Eggs in hysterosoma of the single specimen which I saw spherical, 140 μ in diameter. Adult 800 μ long, 650 μ wide.

HABITAT: A single specimen collected by Cl. Alph. Dugès, in Mexico (Guanajuato), which Cl. Trouessart kindly sent to me.

The swollen form of the leg tarsi, the presence of a single pair of true sensilla on the scutum, and the description of the tarsus of the palp and its terminal setae leave little doubt that this is not a *Diplothrombium* but more likely a *Centrotrombidium*. The eupathidia at the end of the tarsus of *C. approximatum* are almost exactly 30 μ long, while those of *Diplothrombium micidium* are 62 μ long. No known species of *Diplothrombium* has a palpal tarsus which could be described as "conical," but this term could be applied to *Centrotrombidium*. The length of the body is also much more in keeping with *Centrotrombidium* than with *Diplothrombium*. The species should therefore be transferred to the genus *Centrotrombidium*. If it does not belong in that genus, its position there is at least no more untenable than it was in *Diplothrombium*. The only point in which Berlese's diagnosis was out of character with *Centrotrombidium* is in the form of the sensilla. However, a trend toward more slender sensilla is seen in *C. australasiae*, and it is not inconceivable that there might be some species in which these are not swollen.

Johnstoniana George 1909

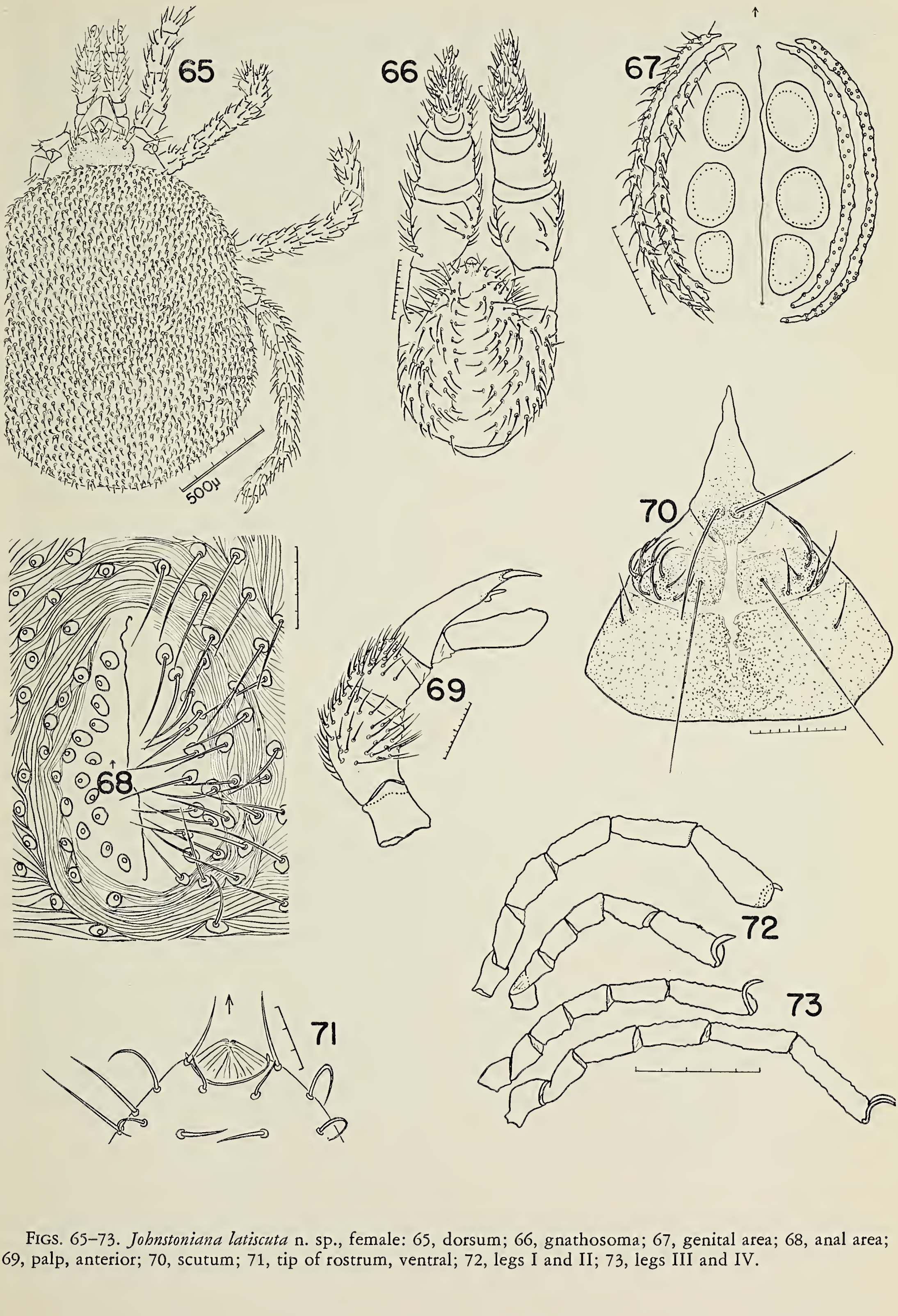
ADULT: Large mites, idiosoma 1,000 to 3,000 μ in length, scutum a broad, roughly pentagonal plate with a prominent anterior spine, two pairs of slender sensilla and a fairly well-developed crista metopica. Lateral to the posterior sensilla is a group of several smooth setae, and in the posterior half of the plate usually one or two somewhat isolated setae. Ocular plates protruding, bicorneate; propodosoma lateral to scutum devoid of setae. Dorsal hysterosomal setae simple, smooth, borne on individual sclerites which may be elevated or not. Coxae I without supracoxal setae; intercoxal area with numerous smooth setae borne on individual sclerites; pars medialis coxae present. Genital and paragenital sclerites well developed, pregenital tubercle absent, three pairs of genital acetabula. Anal sclerites absent in *J. latiscuta* new species. Only two pairs of rostral setae, the deutorostrals apparently absent. Trochanter of palp not fenestrated, considerably longer anteriorly than posteriorly. Palpal tarsus with a single solenidion on posterior surface, and a number of prominent eupathidia. Palpal tibia with a simple terminal spiniform seta, and a single subterminal spiniform seta. Solenidial types s_1 and s_2 distinct, but s_1 and s_4 difficult to differentiate; s_2 relatively short, stout, marked with four longitudinal ridges. Eupathidia present on all segments of all legs including and beyond the telofemur. Vestigial setae present on patella I and II, but absent on tibia I and II.

LARVA: Scutum bearing two pairs of sensilla plus two pairs of other setae, all simple, smooth. Crista metopica present; anterior end of scutum drawn out into a frontal spine. Supracoxal setae absent. Urpore present. Tip of rostrum with only two pairs of setae, the deutorostrals apparently absent. Tarsus of palp with a single solenidion on posterior surface; typical eupathids absent, although the terminal setae of the tarsus are probably modified eupathids. Femora I to III incompletely divided dorsally in *J. latiscuta*. Patella I and II each with a vestigial seta dorsally, but tibia lacking vestigial setae. Dorsal eupathid of tarsus I with a basal companion seta. Tarsi of all legs with two unequal claws.

REMARKS: The structure of the adult scutum as delineated by Berlese and reproduced by various authors is incorrect. Because of the very sharp downward flexure of the scutum between the posterior and anterior sensilla, the configuration of the scutum in undissected specimens is noticeably different from that seen in dissected specimens (Figs. 70, 86). Little is known of the biology of our one North American species except that it is apparently a cold stenothermal species found along mountain streams. *J. errans* (Johnston) 1852 has larvae which are parasitic upon Tipulidiae. Cooreman (1952, p. 109) reported only one case in which he found this ordinarily rare species in great numbers at one point along a small stream in Belgium. This rarity is apparently characteristic of the species described here, for the writer has seen only one female and a larva of *J. latiscuta*. Cooreman reported the capture of 44 females, but no males, which points up the fact that males have not yet been reported for this genus.

Johnstoniana latiscuta new species

FEMALE: Body of ovigerous female about 1816 μ long to tip of scutum, 1330 μ wide, length/width 1.37; color in life a brilliant brick red (Fig. 65). Scutum (Figs. 70, 86) with two pairs of slender, smooth sensilla; plate divided into two portions, a broad extensive posterior portion bearing the posterior sensilla and lateral and posterior to these six to eight setae on either side. The anterior portion is set off by a sharp declivity and bears only the anterior pair of sensilla, in front of which is a rounded knob produced ventrally into a sharp spine. Crista metopica well developed in anterior half of scutum, feebly developed to absent in posterior half. Ocular plates protruding, prominently bicorneate;



Figs. 65–73. *Johnstoniana latiscuta* n. sp., female: 65, dorsum; 66, gnathosoma; 67, genital area; 68, anal area; 69, palp, anterior; 70, scutum; 71, tip of rostrum, ventral; 72, legs I and II; 73, legs III and IV.

cuticle between ocular plates and scutum devoid of setae. Dorsal and marginal body setae (Fig. 84) borne on prominently elevated setigerous sclerites uniformly distributed over the distinctly striated membranous cuticle.

Coxa I with about 60 simple, smooth setae, plus 6 to 9 simple, smooth setae on the pars medialis coxae which appears to be a discrete medial expansion of I (Fig. 82). Supracoxal seta I absent. Coxa II with 45 setae. Membranous area between coxae I and II of right and left sides with 79 smooth setae, borne on individual sclerites. Behind coxa II a wide (75 μ) band of striated cuticle devoid of setae. Marginal setae especially dense between II and III, borne on sclerites which are markedly convex but not cylindrical. In the single specimen available, no trace was found of the characteristic organ just anterior to coxa III in *Lassenia lasseni*. Coxa III with 41 setae; IV with 55 (Fig. 75). No apodemes visible between II and III. Genital opening (Fig. 67) large, with three pairs of genital acetabula; genital sclerites very narrow, crescentic, bearing 34 to 36 slender, smooth setae, mostly in a single to double row. Paragenital sclerites with 52 to 55 similar setae in a single to triple row. The setae on both sets of sclerites are fairly uniformly spaced except at the ends where there are fewer setae than at levels in between. Ventral body setae borne on hemispherical sclerites, membranous cuticle marked with regular but not parallel striae. Anus (Fig. 68) lacking well-defined sclerites, surrounded by cuticle only faintly differentiated from that of rest of venter.

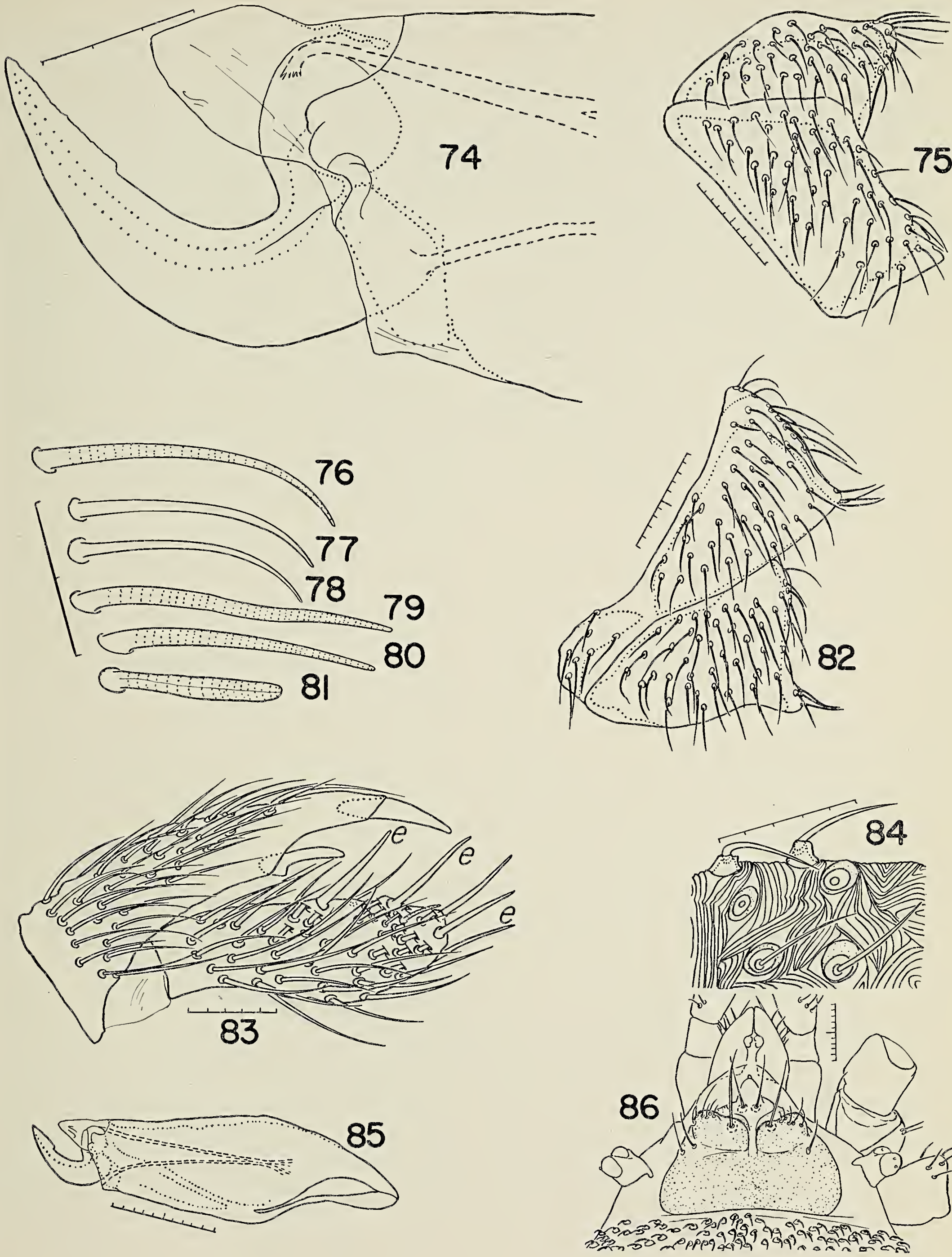
Velum circular to oval in outline, numerous fine filaments converging from a well-defined marginal rim (Fig. 71). Protorostral and tritorostral (? see larva) setae present and well developed; ventral surface of gnathosoma otherwise with 80 to 100 smooth simple setae on either side of the bare mid-ventral line (Fig. 66). Rostrum very short, blunt, extending scarcely beyond the end of the trochanter of the palp.

Chelicerae (Figs. 74, 85) with distal half of tarsal claw slightly raised, knifelike, appearing minutely serrate under oil immersion. Trochanter of palp (Figs. 66, 69) devoid of setae and also without any trace of the fenestration which characterizes the palpal trochanter of the other genera; trochanter considerably longer anteriorly than posteriorly. Terminal segments of palp covered with many long, slender, smooth setae. Tibia with a unidentate terminal seta and a stout subterminal seta at 0.67*v*, the latter bearing a basal tooth or spur. A few of the dorsal setae of the tibia, at least in the distal half, are slightly heavier than the other setae, but are not otherwise different from them. Palpal tarsus with a large eupathid at 0.57*d*, and five other eupathids at 0.73*a*, 0.81*d*, 0.94*v*, 0.95*p*, and 0.97*d*. A single solenidion at 0.84*p* (Fig. 83).

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

All segments of all legs beyond the basifemur with one or more eupathidia, recognizable by their reverse curvature. Vestigial setae fairly long and slender, about half the length of the surrounding solenidia$_3$, confined to patella I and II, absent from tibiae. Tibiae with numerous s_3 (Figs. 77, 78) I and II with only about one seta each which could be assigned to type four. Tarsus I with three s_1 at 0.73*d* to 0.76*pd*, plus four others at 0.27 to 0.33*d* which may possibly belong in this category. Solenidial types s_1 and s_4 are convergent in form and difficult to differentiate. Tarsus I

	tr	bf	tf		pa			ti				ta					
	n	n	s_3	e	s_3	e	v	s_3	s_4	e	v	s_1	s_2	s_3	s_4	e	f
I	18	m	2	1	63	3	1	m	1	4	0	3–7	7	0	m	m	1
II	33	m	1	1	20	3	1	20	1	2	0	4	1	0	10±	20±	1
III	30	m	1	1	26	2	0	16	0	3	0	0	0	0	7±	3,4	0
IV	40	m	1	1	35	2	0	28	0	2	0	0	0	5±	0?	2	0



FIGS. 74–86. *Johnstoniana latiscuta* n. sp., female: 74, end of chelicera; 75, coxae III and IV; 76, solenidion$_4$, tibia I; 77, s_3, patella I; 78, s_3, femur I; 79, s_1, tarsus I; 80, s_1, tarsus II; 81, s_2, tarsus I; 82, coxae I and II; 83, tibia and tarsus of palp, posterior; 84, hysterosomal setae; 85, chelicera; 86, propodosoma.

also with seven s_2 at $0.72pd$ to $0.92pd$, these being short, slightly clavate, and longitudinally ribbed; s_3 absent, s_4 numerous. Many eupathidia extending from $0.36v$ to $0.20d$. Famulus$_1$ at $0.70d$ very similar to the eupathidia in form, but somewhat shorter and broader at the base. Tarsus II with four solenidia$_1$, at 0.23, 0.38, 0.54 and $0.57d$; a single s_2 at $0.60d$, at the base of the claw fossa. Precise number of s_4 not determinable with material available; eupathidia numbering about 20. Famulus$_2$ at $0.57d$ very small, short, peglike, easily overlooked. Tarsus III with about seven solenidia intermediate to types s_3 and s_4, but more closely resembling the latter. Tarsus IV with about five solenidia, which appear to belong to type s_3.

MALE: Unknown.

LARVA: Only one specimen of the larva was taken and this was in such poor condition that neither measurements nor counts of the numerous body setae could be made. Scutum (Fig. 90) with two pairs of smooth, slender sensilla and two pairs of finely barbed setae (oil immersion). Anterior end of scutum with a knoblike projection bearing at its tip a smaller conical projection. Crista well developed; extending to level of anterior sensilla. Cuticle finely and densely punctate. Dorsal and marginal body setae slender, tapering to a very fine point, and smooth; each seta borne on an individual sclerite which is rather feebly delimited from the surrounding unstriated membranous cuticle.

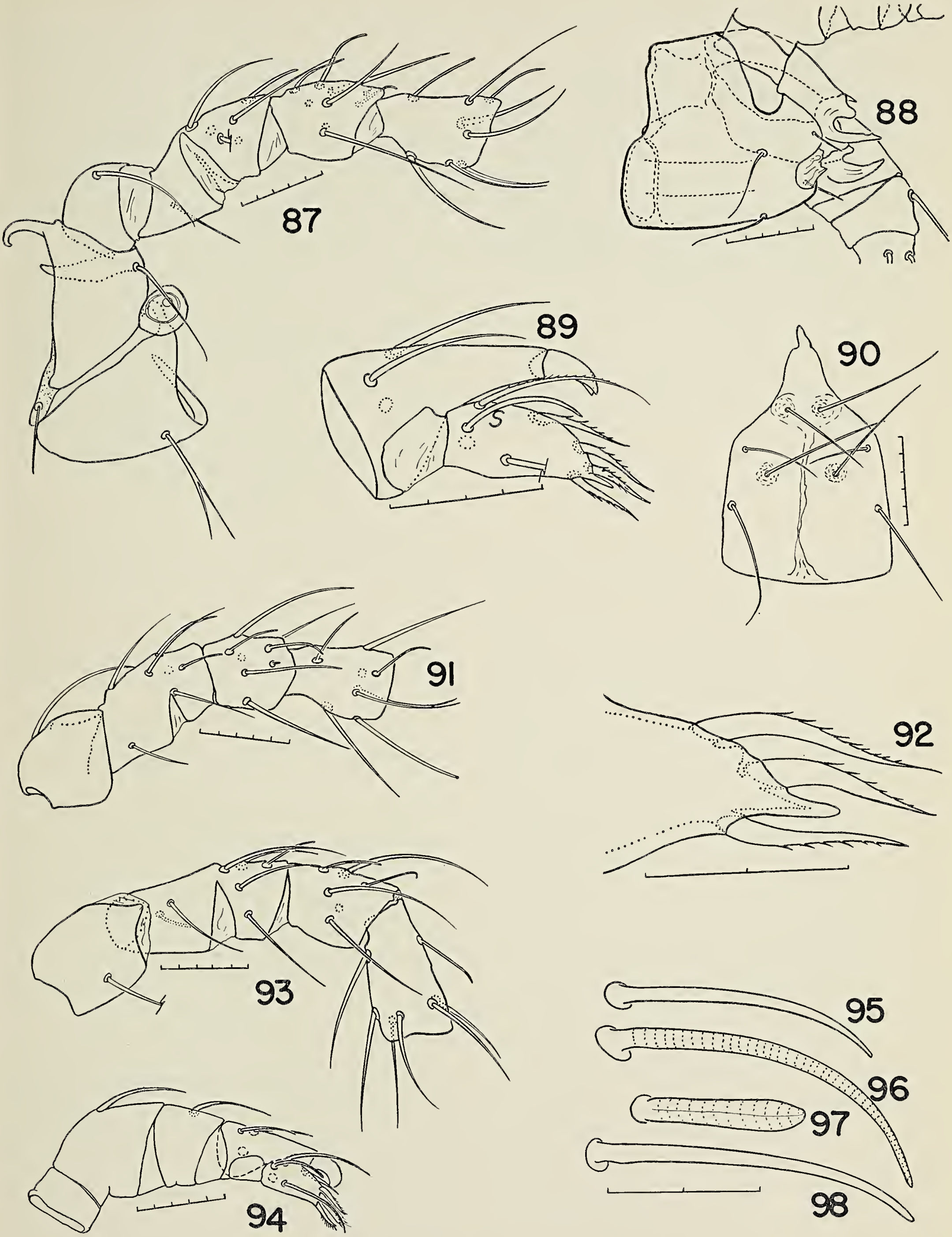
Coxa I with two setae, including the one on the rather well-developed pars medialis coxae, II and III each with a single seta, that on II bifurcate on both right and left sides of the single specimen available (Figs. 87, 101). Urpore well developed. Supracoxal setae on I apparently absent but material not very satisfactory for study.

Gnathosoma bearing only two pairs of setae, the protorostrals and probably the tritorostrals, the deutorostrals apparently absent (Fig. 88). Supracoxal setae absent. Rostrum short, blunt; velum simple. Chelicerae short, compact, tarsus scythe-shaped with one or two small teeth near the tip. Palpal trochanter (Fig. 94) without setae, femur and patella with a single seta dorsally which appears smooth at low magnifications, but at high magnifications can be seen to have three or four very minute barbs. Tibia with three normal setae in basal half, plus the bidentate terminal clawlike seta. Tarsus with a solenidion very near the base, three long, slender, normal setae also in basal half plus four heavy pectinate setae in distal half. Typical eupathids are absent, although the four hemipectinate setae in the distal half of the segment evidently represent the eupathids of the adult.

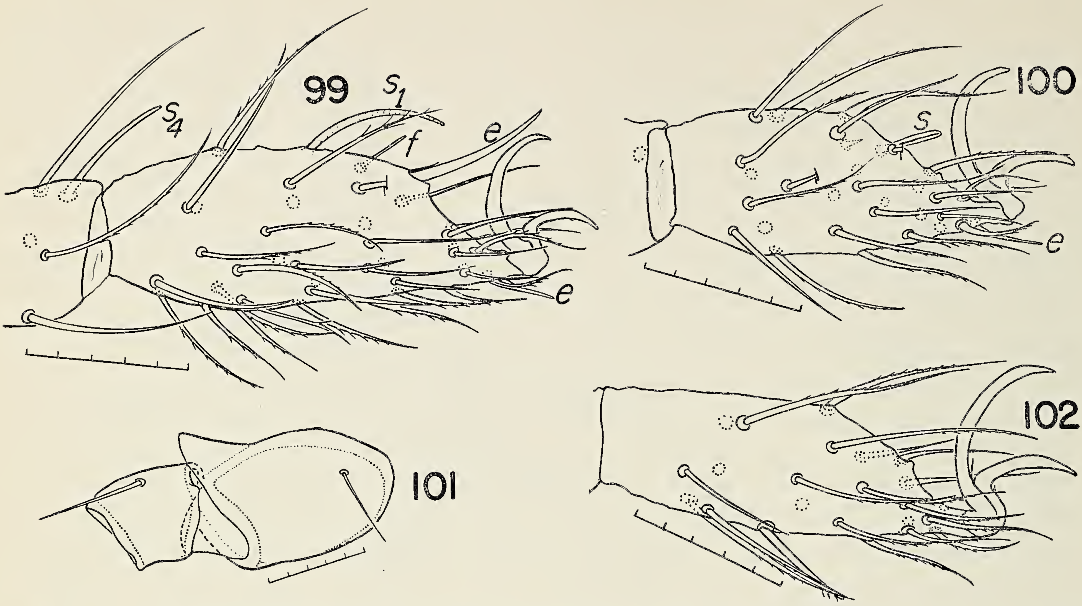
Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Femora I to III (Figs. 87, 91, 93) incompletely divided; with a well-developed synarthrodial membrane ventrally but the cuticle in the dorsal part of the segment continues with no trace of interruption from the basifemoral to the telofemoral portion. Although there is no true articulation dorsally as found between other segments of the leg, there is undoubtedly considerable flexibility at this joint. Telofemoral portion of femur, patella and tibia of all legs with one or more solenidia$_3$ dorsally. Patella I and II each with a vestigial seta dorsally, but tibiae lacking vestigial setae. Tarsus I (Fig. 99) with annulate dorsal solenidion$_1$ at $0.45d$, a straight, elongate, smooth famulus at $0.56pd$, eupathid and

	tr	bf	tf		pa				ti				ta					
	n	n	s_3	n	s_3	s_4	v	n	s_3	s_4	v	n	s_1	s_2	e	f	c	n
I	1	1	1	5	4	0?	1	4	0	2	0	6,7	1	0	2	1	1	37
II	1	2	1	4	2	0?	1	4	1	1	0	6	0	1	1	1	0	28
III	1	2	1	4	2	0	0	4	1	1	0	6	0	0	0	0	0	23



FIGS. 87–98. *Johnstoniana latiscuta* n. sp., larva: 87, leg I, and coxae I and II; 88, gnathosoma, ventrolateral; 89, tibia and tarsus of palp, posterior; 90, scutum; 91, leg II, trochanter to tibia; 92, tip of palpal tarsus; 93, leg III, trochanter to tibia; 94, palp, posterior; 95, solenidion$_3$, patella II; 96, s_1, tarsus I; 97, s_2, tarsus II; 98, s_4, tibia I.



FIGS. 99–102. *Johnstoniana latiscuta* n. sp., larva: 99, tarsus I, anterior; 100, tarsus II, anterior; 101, coxa III; 102, tarsus III.

companion seta at 0.70*d*, and a shorter one at 0.88*pv*. Tarsus II with short, spikelike famulus$_2$ at 0.50*pd*, a clavate, carinate solenidion$_2$ at 0.59*pd*, and a rather straight eupathid at 0.84*pv*. Tarsus III with no specialized setae. Anterior and posterior claws on all legs with a sharp spine at the basal third of the concave side; anterior claw gently curved throughout length, posterior claw sharply bent just beyond the spine.

TYPE LOCALITY: At origin of King's Creek, Lassen Volcanic Park, California, August 6, 1955 (holotype female). Collected by the writer. Type in author's collection.

REMARKS: The correlation of the female with the larva described above must be regarded as tentative, although it is almost certain that they belong to the same species. The two specimens were found within about a foot of each other under rocks on the edge of the stream. There is no question about their generic identity.

It is not possible to compare this species with other presently described forms because of the inadequacies of the description of the latter. However, it is probable that detailed comparisons would prove it distinct.

Johnstoniana vitzthumi Womersley 1939

While it is apparent from the original figures and description that this species belongs in the Johnstonianidae, it is impossible to compare it reliably with other members of the family, or even to ascertain that it is truly a *Johnstoniana*. The description was based on a single specimen collected in South Australia.

Diplothrombium Berlese 1910

ADULT: Fairly large mites, idiosoma usually between 1,000 and 2,000 μ long, color in life dark reddish-brown. Scutum elongate, narrow, bearing an anterior spine, and well-differentiated anterior and posterior areae sensilligerae (Figs. 110, 160). Two pairs of smooth, slender sensilla, and usually two pairs of shorter normal setae in the posterior area sensilligera. Dorsum of propodosoma with a few to many setae borne on individual

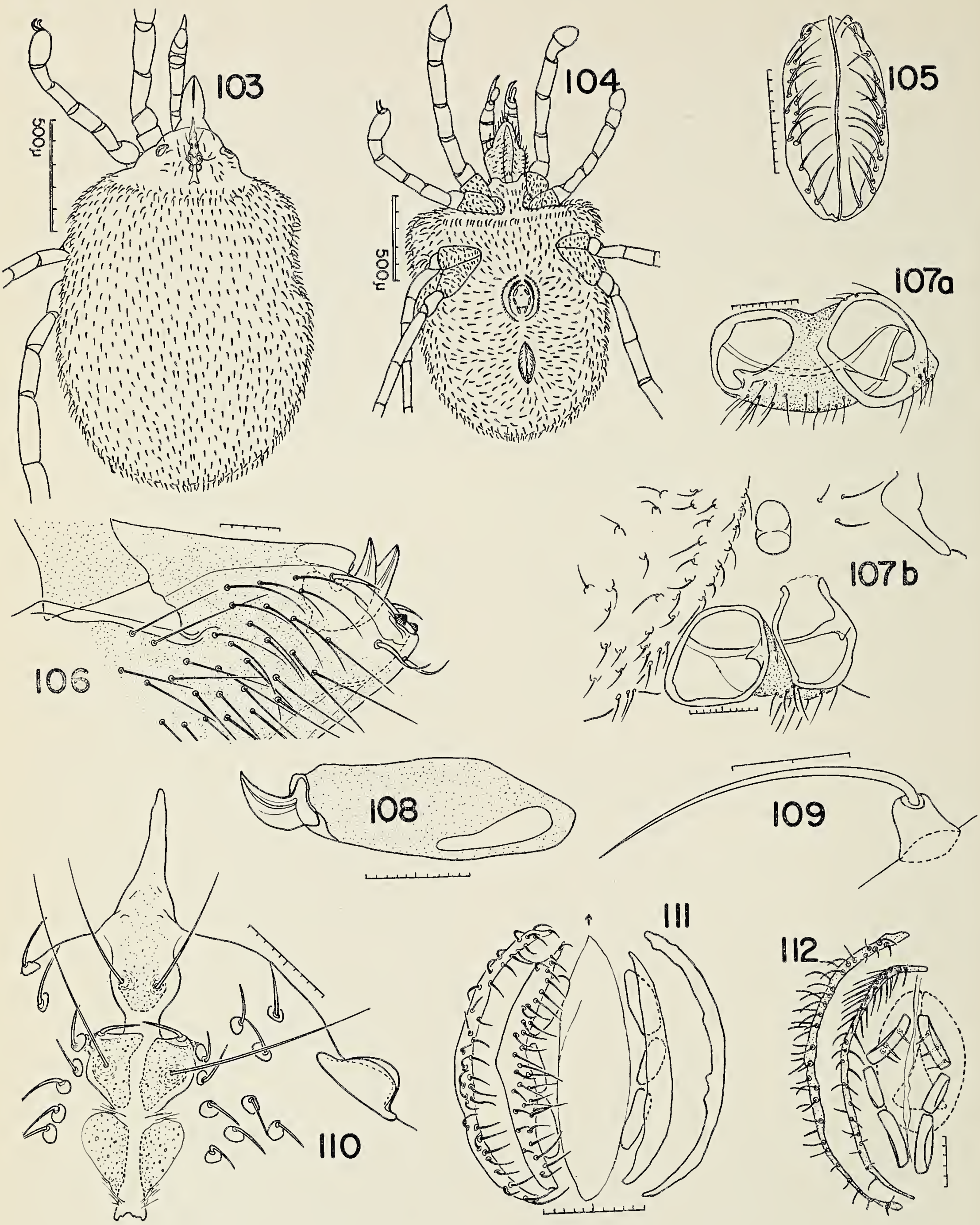
sclerites between the scutum and ocular plates. Dorsal hysterosomal setae smooth, borne on individual elevated sclerites. Ocular plates protruding moderately, bicorneate. Coxa I lacking supracoxal setae; coxal ring of II complete dorsally, that of coxa I membranous dorsally. Intercoxal area with numerous smooth, slender setae, each borne on individual sclerites; pars medialis coxae well developed. Genital and paragenital sclerites well developed, three pairs of genital acetabula. Anal sclerites crescentic, bearing a number of smooth setae. Rostrum apparently only with the protorostral and tritorostral setae, plus other setae behind these; deutorostrals absent. Trochanter of palp fenestrated anteriorly; tibia with one large terminal and one subterminal clawlike seta. Tarsus of palp with a single solenidion posteriorly, and a number of eupathidia in the distal half. Legs with solenidia of four fairly distinct types, s_2 being especially distinctive, clavate. Eupathidia present on all segments of all legs including and beyond the telofemur. Vestigial setae completely absent.

LARVA: Scutum with two pairs of sensilla, the anterior pair very small; otherwise with two pairs of normal setae. Crista metopica well developed, anterior portion of scutum produced into a process of variable form. Ocular plates bicorneate. Dorsal and ventral surfaces of body covered with numerous setigerous sclerites. Coxal setae numbering 2–1–1 in known species. Intercoxal area with a single pair of setae between III; urpore present. Gnathosoma bearing only two pairs of setae, probably the protorostrals and tritorostrals. Supracoxal setae absent on both the gnathosoma and on leg I. Podocephalic canals well developed. Anterior wall of trochanter of palp fenestrated. Palpal tarsus with a single solenidion near basal end; eupathidiform setae absent, although some of the terminal setae must be modified eupathidia. Solenidia$_3$ present on telofemur of legs I to III; s_1 elongate, somewhat decumbent, s_2 stout, clavate. Tarsus II with only one eupathid. All legs with six free segments beyond the coxa, and two subequal tarsal claws.

REMARKS: The larvae described here are the first described for the genus as a whole, and, of course, *D. monoense* is the first species in which the larva and adult are both known. Species of this genus are found in very moist situations and are cryptic in habits, avoiding direct sunlight as much as possible. Although experimental evidence is not yet available, they are evidently incapable of tolerating high temperatures for any length of time. The larvae are of the self-detaching type; they have been found parasitizing the pupae of aquatic beetles under wet rocks.

Diplothrombium monoense n. sp.

FEMALE: Idiosoma (Fig. 103) highly variable in size, 1,638 to 1,820 μ long, 1,092 to 1,326 μ wide, length/width 1.43 to 1.52; average 1,706 by 1,180 μ, length/width 1.45 (five ovigerous specimens). Scutum (Fig. 110) with two pairs of completely smooth sensilla, and between them a pair of stiff setae appearing hemipectinate under high magnification. Posterolateral to these is a second pair of setae contiguous with, but not fully enclosed by the scutum. Anterior end of scutum produced into a long blunt spine. Crista metopica well developed, extending from posterior margin of anterior area sensilligera to posterior end of scutum. Behind the posterior area sensilligera is a lateral expansion on either side of the crista metopica, bearing a number of coarse punctations. Ocular plates small, scarcely larger than the two corneae found on each side, strongly convex but not stalked, setae absent. Dorsal and marginal body setae (Fig. 109) smooth, slender, tapering, typically with a sharp basal flexure. Alveoli borne on individual sclerites which are sharply elevated above the general surface of the cuticle in the form of a truncate cone. Propodosomal cuticle between the scutum and ocular plates and lateral to the ocular plates generally with



FIGS. 103–112. *Diplothrombium monoense* n. sp.: 103, dorsum, female; 104, venter, male; 105, anus, male; 106, gnathosoma, male, lateral; 107a, coxae III and IV, male, lateral; 107b, coxae I and II, male, lateral; 108, chelicera, female; 109, hysterosomal seta, female, side view; 110, propodosoma, female; 111, genital opening, female: 112, genital opening, male.

fewer than ten setae. Cuticle seemingly devoid of striae or other markings except for the underlying reticular layer.

Coxae I and II (Fig. 122) with about 50 and 60 setae respectively, plus 7 to 10 setae on the pars medialis. All setae smooth. No supracoxal setae; coxal ring I open dorsally, II closed dorsally (Fig. 107b). Coxae III and IV with 70 to 75 setae each, coxal ring of each complete dorsally (Fig. 107a). Cuticle of all coxae faintly punctate. Intercoxal area between I and II with 65 to 70 smooth slender setae, each borne on a small sclerite; a narrow band of cuticle behind coxae I and II devoid of setae. No sclerotized plates in the membranous area between coxae II and III. Ventral body setae like those on dorsum, except that the sclerites are not so prominently raised. Genital sclerites (Fig. 111) bearing 35 to 45 smooth slender setae; paragenital sclerites narrower than genital sclerites but bearing 43 to 50 setae of the same form as those on the genital sclerites (three specimens). Genital acetabula well developed, the second pair the smallest. Anal sclerites (Fig. 105) quite variable, with from 11 to 19 setae arranged in a single to double row; setae similar to those on genital sclerites.

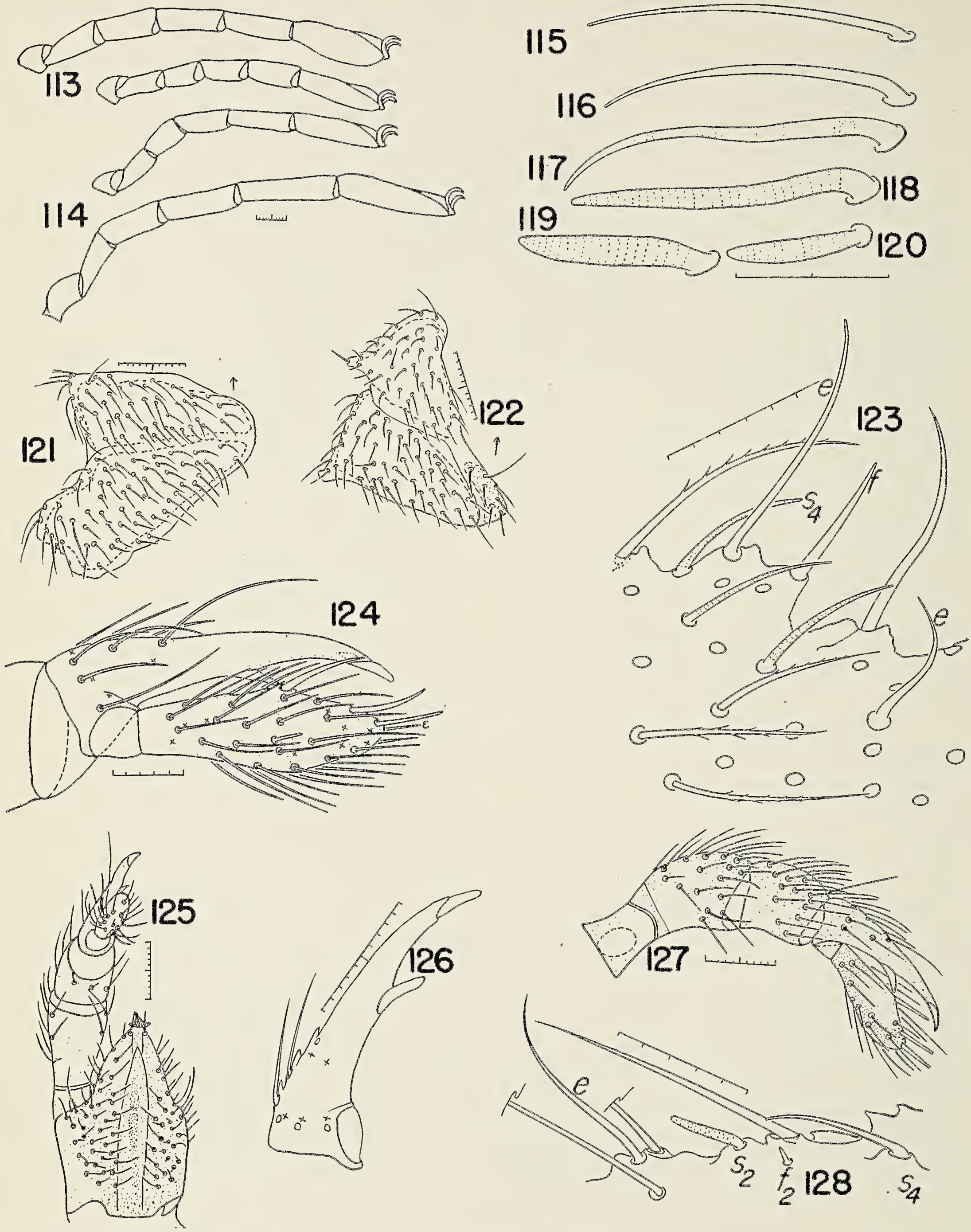
Base of gnathosoma and rostrum bearing about 45 setae on each side, supracoxal setae absent. Rostrum relatively short and broad; tip of rostrum (Fig. 106) with two pairs of specialized setae, presumably the protorostrals and tritorostrals. Velum small, circular, and oriented in an anterior direction (Fig. 125). Chelicerae as shown in Figure 108. Trochanter of palp (Fig. 127) devoid of setae; medial wall fenestrated. Tibia with a heavy spiniform seta at 0.58*v* and a second one at the end of the segment. A series of three very sharp spines dorsally, in basal third of tibia (Fig. 126). Tarsus with a large eupathid borne on a prominent tubercle at 0.61*d* and a group of two large and two small eupathids near the tip of the segment (Fig. 124). A single solenidion at 0.57*p*. Normal setae of palp smooth and tapering.

Trochanters I and II with about 8 setae dorsally, three with about 10 setae dorsally, and four with 20 to 25 setae, all these setae smooth to faintly hemipectinate. All basifemora lacking specialized setae, normal setae on dorsal portions of segment smooth to faintly hemipectinate, those on ventral half of segment usually very fine and smooth.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Vestigial setae absent from all legs. Tarsus I with famulus elongate, erect, its alveolus located on a prominent tubercle at 0.31*pd* (Fig. 123). Solenidion$_1$ actually smaller than the corresponding seta on tarsus I of the larva, inserted at 0.52*d* at the origin of the claw fossa. A group of five thick, stout s_2 extending from 0.57 to 0.80*p*. These are generally slightly smaller than the corresponding setae on tarsus II but are the same general form and are internally annulate. Eupathidia very numerous, extending from 0.26*v* to 0.13*d*, or in other words around nearly the entire periphery of the tarsus I. Basal portion of tarsus I from about 0.30*v* to 0.52*d*, extremely rough, provided with sharp, truncate tubercles. These tubercles bear the alveoli of a number of types of setae including the famulus, eupathidia, solenidia$_4$, and bihemipectinate normal setae. The normal setae on all segments of the legs are smooth or very nearly so, with the exception of those of tarsus I. Tarsus II with a clavate s_2 at 0.49 to 0.50*d*, and a spikelike

	tr	bf	tf		pa			ti			ta					
	n	n	s_3	e	s_3	s_4	e	s_3	s_4	e	s_1	s_2	s_3	s_4	e	f
I	7–9	m	16	3	60	2	2	55	2	2	1	5	0	m	m	1
II	7	m	10	3	22	3	3	10	5	3	0	1	0	5	4	1
III	9–11	m	10	3	30	1	2	11	5	3	0	0	0	2	8	0
IV	20–23	m	6	2	30	2	3	13	4	4	0	0	0	4	8	0



FIGS. 113–128. *Diplothrombium monoense* n. sp.: 113, legs I and II, female; 114, legs III and IV; 115, solenidion$_3$, telofemur I; 116, s_3, tibia I; 117, s_4, tarsus I; 118, s_1, tarsus I; 119, s_2, tarsus II; 120, s_2, tarsus I; 121, coxae III and IV, female (115–120 all female); 122, coxae I and II, female; 123, famulus and other setae of tarsus I, female; 124, tibia and tarsus of palp, female, posterior; 125, gnathosoma, female; 126, tibia of palp, female; 127, entire palp, female; 128, tarsus II, female.

famulus at 0.45 to 0.52*d*, these setae of the same form as the corresponding ones in the larva. Tarsus II apparently lacking s_1, the remaining solenidia being s_4 (Fig. 128). All tarsi with a distinct claw fossa on dorsal surface, and most segments of legs with exception of trochanter and basifemur bearing many angular dorsal protuberances which give the legs a rough appearance. Two claws on all tarsi, the claws flattened and with a median ventral carina.

MALE: Similar to female in most respects observed, with the principal exception of the genital opening (Fig. 112). Genital opening guarded by two pairs of sclerites as in female, but these have many more setae. Anterior 0.4 of each genital sclerite with 45 to 50 close-packed smooth, long, slender setae; remaining 0.6 with only about 20. Paragenital sclerites each with about 40 to 45 smooth setae, 6 or 8 of which are appreciably heavier than the others. Penis not triangular, but small and tubular. Three pairs of prominent genital acetubula. Anal sclerites with 14 to 17 smooth, slender setae.

LARVA: Body 343 to 389 μ long, 233 to 279 μ wide, length/width = 1.36–1.57; average 369 by 253 μ, length/width = 1.46 (five specimens). Scutum (Fig. 129) with a knob-like protuberance anteriorly, and a pair of very small sensilla inserted near the base of this. The knob bears a short, blunt point ventrally, but this is not visible in dorsal view. These setae, while not especially sensillar in form, are forerunners of the anterior sensilla in the adult. Setae at anterolateral and posterolateral angles bihemipectinate. Posterior sensilla very long, slender, smooth. Crista metopica well developed in anterior one-half (sometimes in posterior one-third also) of scutum. A patch of moderately coarse pores (250 x) near posterior margin; surface otherwise marked with numerous fine punctae and an irregular reticulum medially behind the sensilla. These pores and reticulae are also evident in the adult (Fig. 110). Corneae two on each side, borne on a common ocular plate. Dorsal setae 36 in number, borne in five transverse rows (8, 8, 8, 8, 4; Fig. 131). Each seta faintly hemipectinate (250 x), borne on an individual sclerite, the central portion of which is moderately elevated (Fig. 130). Membranous cuticle with parallel striae, which are sometimes indistinct.

Coxa I (Fig. 144) with two bifurcate setae; medial portion of coxa caudiform, indistinct. Supracoxal seta absent. Coxa II with one bipectinate seta laterally; coxa III with one smooth seta. Intercoxal area (Fig. 138) with only one pair of setae between coxae III; postcoxal area with 36 to 38 hemipectinate ventral and marginal setae on each side, all borne on individual sclerites. Presumptive anal opening distinct.

Gnathosoma with a single pair of bifurcate setae ventrally, presumably the tritorostrals. Rostrum very short; protorostral setae smooth. Velum small. Podocephalic canals well developed. Supracoxal setae absent. Cheliceral base very thick; digitus fixus membranous (Fig. 134); digitus mobilis smooth, except for one tooth. The ventral margin of the digitus mobilis in the specimen drawn was bent, but this may not be normal. Palpi five-segmented (Fig. 133). Trochanter lacking setae, femur and patella each with one long, smooth dorsal seta. Tibia with three smooth setae and a hooked terminal spiniform seta which usually appears unidentate in lateral view, but bifid in ventral view. Palpal tarsus (Figs. 132, 136) with solenidion basally on lateral surface. Tip of tarsus drawn out into a flat, sharp spine; a faintly pectinate seta arising dorsally at the base of the spine gives the tarsus a bifid appearance. Otherwise with six setae, all but two of which are faintly hemipectinate. No typical eupathidiform setae present, although the heavy pectinate setae are quite certainly the forerunners of these.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, n = normal setae).

Trochanters I to III each with one large ventrally curved seta. Basifemora all distinctly

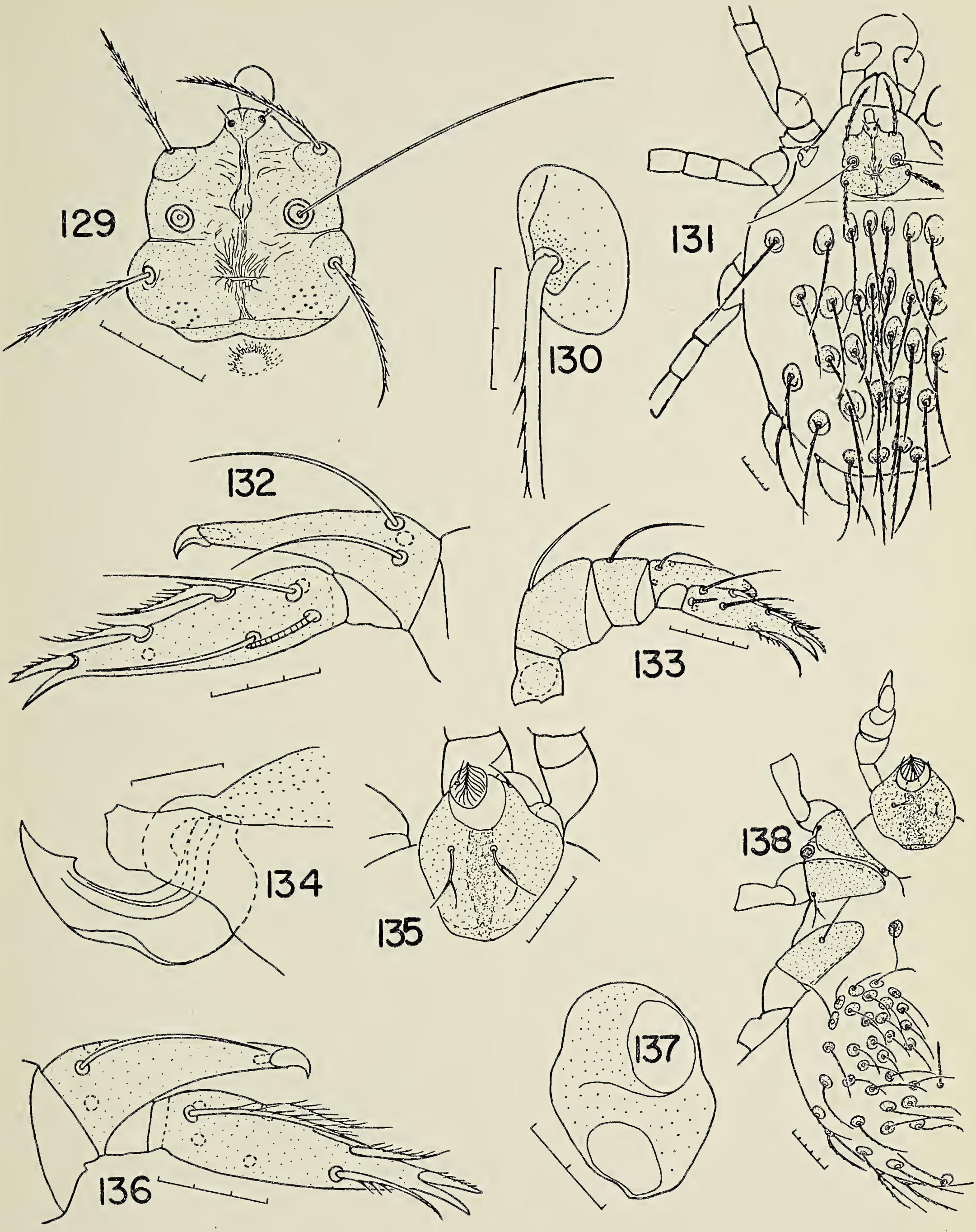
	tr	bf	tf		pa		ti			ta				
	n	n	s_3	n	s_3	n	s_3	s_4	n	s_1	s_2	e	f	n
I	1	1	2	5	15	4	1	1	6	1	0	2	1	34
II	1	2	1	4	2	4	0	2	6	0	1	1	1	27
III	1	2	1	4	2	4	0	1	6	0	0	0	0	20

separated from telofemora; I with a large ventral seta, but no dorsal seta, II and III each with a large hemipectinate dorsal and a small, smooth ventral seta. Telofemur I with two dorsal solenidia$_3$ (Figs. 139–141), II and III with one each; otherwise with 5, 4, and 4 smooth to faintly pectinate setae respectively. Vestigial setae and companion setae absent from all segments of all legs. Tarsus I (Fig. 143) with a long famulus at 0.42*pd* and a long solenidion$_1$ at 0.44*d*, the latter lacking annular structure, but with internal surface granular (oil immersion). Solenidion, when seen in dorsal view, not straight, but very gently bisinuate. A long eupathid at 0.66*d*, but no companion seta, and a shorter one at 0.93*v*. A pair of long, slender setae at 0.87 and 0.89*ad* and *pd*, and another at 0.88*av*. Otherwise with 31 bihemipectinate setae in specimen drawn. Tarsus II (Fig. 145) with famulus at 0.45–0.52, a club-shaped solenidion$_2$ at 0.55*d*, three slender, smooth setae at 0.80*d*, 0.83*d*, and 0.83*v*, and a eupathid at 0.89*pv*. Otherwise with 24 bihemipectinate normal setae in specimen drawn. Tarsus III (Fig. 142) with five slender, smooth setae at 0.79*d* to 0.86*v*. Otherwise with 15 bihemipectinate normal setae on tarsus drawn. Two claws on all tarsi, the anterior one larger than the posterior one; all claws smooth.

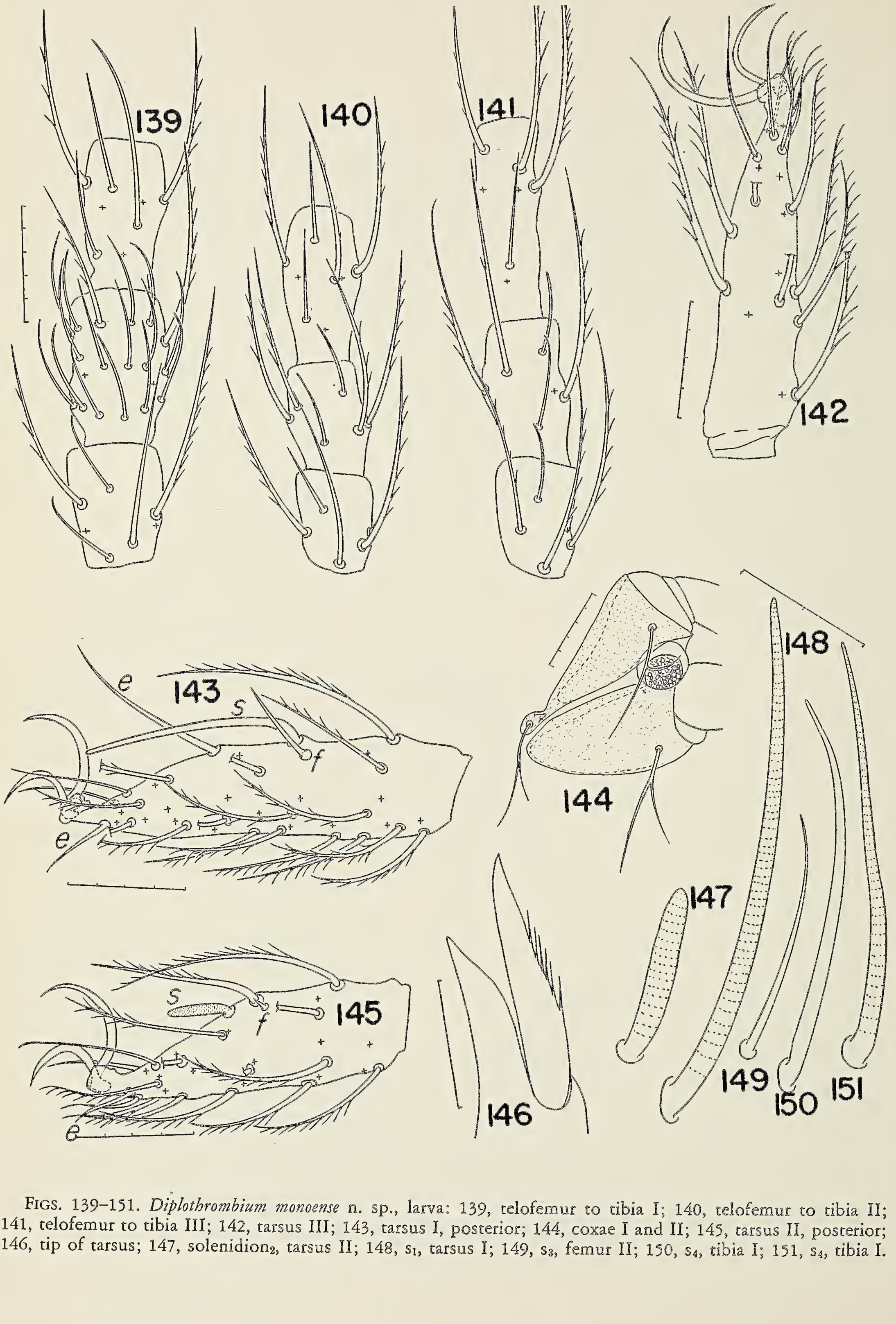
TYPE LOCALITY: Mono Lake, Mono County, California, 0.9 miles north of Leevining (holotype female). Type in author's collection.

REMARKS: These mites were first found on and under rocks, lying in and near a small tricklet of alkaline water running into the lake, June 1, 1952. The habitat could be termed semiaquatic. The bottom of one rock was covered with scores of pink eggs laid singly and several other rocks were also observed with smaller numbers of eggs but always in association with these adults (June 1, 1952). Eight larvae were found attached to the pupa of an aquatic beetle found under a stone. The larvae were definitely attached to the host and appeared to be feeding, but when submerged in alcohol the larvae immediately detached themselves from the host. The feeding habits of the adult are unknown at present. The same spot was revisited July 1, 1954. A few adults were found at this time, but no eggs, indicating that the reproductive season terminated sometime during the month of June. The same picture was observed when the spot was again revisited August 9, 1955 —although adults and nymphs were fairly common, no eggs or larvae whatever were found.

While found at a site in which very high summer temperatures are registered in exposed places, *Diplothrombium monoense* was never found out in the open where it would be subject to these high temperatures. Also it was never found in situations where there was not considerable moisture, and the majority were found under rocks in which the surface of the ground was actually wet. A few individuals were running about over the surface of very wet ground covered with a dense growth of small plants. Under such circumstances they always appeared restless, especially when their cover was removed so as to expose them to the direct rays of the sun. A species of *Microtrombidium* was also very common at this locality but was frequently found running about over the surface of the dry sand along the shore of the lake, even in the heat of the day. Their movements were generally rapid, but at least they did tolerate the exposure to heat and sun for short periods of time. This species of *Diplothrombium* would appear to be considerably less tolerant of heat and dryness than species of *Microtrombidium*. Fur-



FIGS. 129–138. *Diplothrombium monoense* n. sp., larva: 129, scutum; 130, dorsal seta; 131, dorsum; 132, tibia and tarsus of palp, posterior; 133, entire palp, posterior; 134, end of chelicera; 135, gnathosoma, ventral; 136, tibia and tarsus of palp, anterior; 137, ocular plate; 138, venter.



FIGS. 139–151. *Diplothrombium monoense* n. sp., larva: 139, telofemur to tibia I; 140, telofemur to tibia II; 141, telofemur to tibia III; 142, tarsus III; 143, tarsus I, posterior; 144, coxae I and II; 145, tarsus II, posterior; 146, tip of tarsus; 147, solenidion$_2$, tarsus II; 148, s_1, tarsus I; 149, s_3, femur II; 150, s_4, tibia I; 151, s_4, tibia I.

ther evidence of the narrow temperature tolerance of *D. monoense* was obtained through an unfortunate mishap. A number of adults being brought back to Riverside for rearing studies were killed during the eight-hour transit of the Mojave Desert, despite precautions taken to insulate them from the heat. The same was true of the living specimens of *Lassenia lasseni*—none survived the trip across the desert. At the same time a species of *Microtrombidium* collected at an elevation of 8,000 feet on the slopes of Mt. Lassen did survive, laid eggs, and these eggs eventually hatched. A species of Erythraeidae also survived the exposure to high temperature which was lethal to the two species of Johnstonianidae. The rather low heat tolerance of these species undoubtedly is important in determining their distribution, both geographically and locally.

The correlation between larva and adult was established on the basis of their coexistence at the type locality. More than 90 adults or nymphs and 50 larvae have been collected there, and there is apparently only one species involved.

Diplothrombium micidium new species

FEMALE: Body (Fig. 152) 936 μ to tip of scutal spine, 546 μ wide, length/width 1.48 (one ovigerous female). Scutum (Fig. 160) produced into a stout conical spine anteriorly. Crista metopica well developed, extending from posterior end of scutum to base of spine. Two pairs of sensilla present, the posterior pair borne on the widest portion of the scutum; sensilla completely smooth. Just in front of the posterior sensilla are two pairs of smooth setae, and just lateral to the sensilla a third pair of setae which lie either in the very margin of the scutum or possibly in some cases just outside. The rather broad plate found behind the posterior area sensilligera in *Diplothrombium monoense* is also found in this species but it is small and easily overlooked at low magnification. Ocular plates very small, bearing two protruding corneae; devoid of setae. Dorsal propodosomal cuticle containing about 20 setae on each side between the ocular plate and the scutum; each of these setae is borne on a small sclerite. Dorsal hysterosomal setae (Fig. 167) also borne on individual sclerites, the shaft sharply deflexed at the origin of the seta from the alveolus. Membranous cuticle of dorsum smooth, subcuticular reticulum present but not very prominent. Coxae I and II (Fig. 154) each with about 30 or 31 smooth simple setae, pars medialis coxae with three to four setae each borne in an oval area within the pars. Outside of these oval areas the pars medialis is distinctly reticular in appearance. Supracoxal setae absent on I. Intercoxal area with about 60 setae borne on individual sclerites in the specimen studied (not all shown in the figure), these setae smooth and simple. Two to three narrow refractile chitinous rods in the membranous cuticle behind coxa II; a band of membranous cuticle behind coxa II devoid of setae. Coxae III and IV (Fig. 165) each with about 25 to 30 setae. Genital sclerites (Fig. 164) with 10 and 12 setae each in a single row; paragenital sclerites with 19 and 22 setae each in a single to double row. Three pairs of genital acetabula present. Anal sclerites narrow, crescentic, bearing 9 smooth setae each in the specimen studied (Fig. 158). Ventral setae of hysterosoma all borne on individual sclerites as on dorsum.

Rostrum (Fig. 154) with telorostral and deutorostral setae well developed; remainder of rostrum and base of gnathosoma with 30 setae on each side of the mid-line; mid-ventral portion of gnathosoma devoid of setae. Velum small, anteriorly directed, with numerous converging filaments. Base of chelicera (Fig. 166) compact, densely and minutely punctate; dorsal membrane blunt, tarsus stout, curved, dorsal margin appearing smooth at low magnifications but with a very large number of minute teeth at magnifications above 250 x. Palpi (Fig. 153) with trochanter fenestrated on anterior surface, femur with 20

to 25 setae, patella with about 20 setae. Tibia of palp (Fig. 159) with a few sharp spines along the dorsal margin, 10 simple, smooth setae, plus the terminal clawlike seta and the heavy subterminal seta on the anterior aspect. Tarsus of palp with a solenidion at 0.50*p*, a eupathid at 0.64*d* and four additional eupathids at or near the end of the segment, plus 27 smooth setae. On the right palp of the specimen drawn there was a sharp spine at 0.79*d*, just anterior to the dorsal eupathid; on the left palp no such spine was found in this position, but one was found at 0.8*v*. Chaetotaxy of legs essentially as described for male.

MALE: Body 1,014–1,066 μ long, 520–598 μ wide, length/width 1.78–1.95 (average of 3 specimens 1,040 by 554 μ, average length/width, 1.88). Resembling female in all essential respects except structure of genital area. Genital sclerites (Fig. 155) with 16 to 18 setae in a single to double row, paragenital sclerites with 23–26 setae, also in a single to double row; an internal circlet of about 7 pairs of setae. Genital acetabula numbering three pairs. Anal sclerites as described for female.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, n = normal setae, m = many).

All legs with telofemur to tarsus very rough in appearance (Figs. 162, 163). Solenidia exceptionally well defined, with no intergradation between types; s_3 slender, with no internal structure, s_4 bacilliform with usually distinct internal structure, somewhat variable in length. Solenidia$_1$ and s_2 are not unlike s_3 in general appearance, but differ principally in length and moreover occupy characteristic positions on the tarsi. Solenidia$_4$ absent from all but tarsus of leg I, but present on telofemur to tarsus of legs II to IV. Vestigial setae absent from all legs. Tarsus I with famulus at 0.65*d*, this seta resembling a eupathid but somewhat shorter. Solenidion$_1$ at 0.80*d*, and three s_2 at 0.63, 0.76, and 0.87*p* (Fig. 161). Tarsus II (Fig. 156) with spikelike famulus at 0.59*d*, s_2 at 0.60*d*, and a group of five s_4 at 0.18*d* to 0.49*p*. Tarsus II with only two eupathidia, one at 0.54*pd*, the other at about 0.95*pv*. Eupathidia present on all segments of all legs beyond the basifemur, but few in number, rarely exceeding three except on tarsus I. Eupathidia of tarsus I extending from 0.35*v* to 0.39*d*. All tarsi with two slightly subequal claws and a rather small claw fossa.

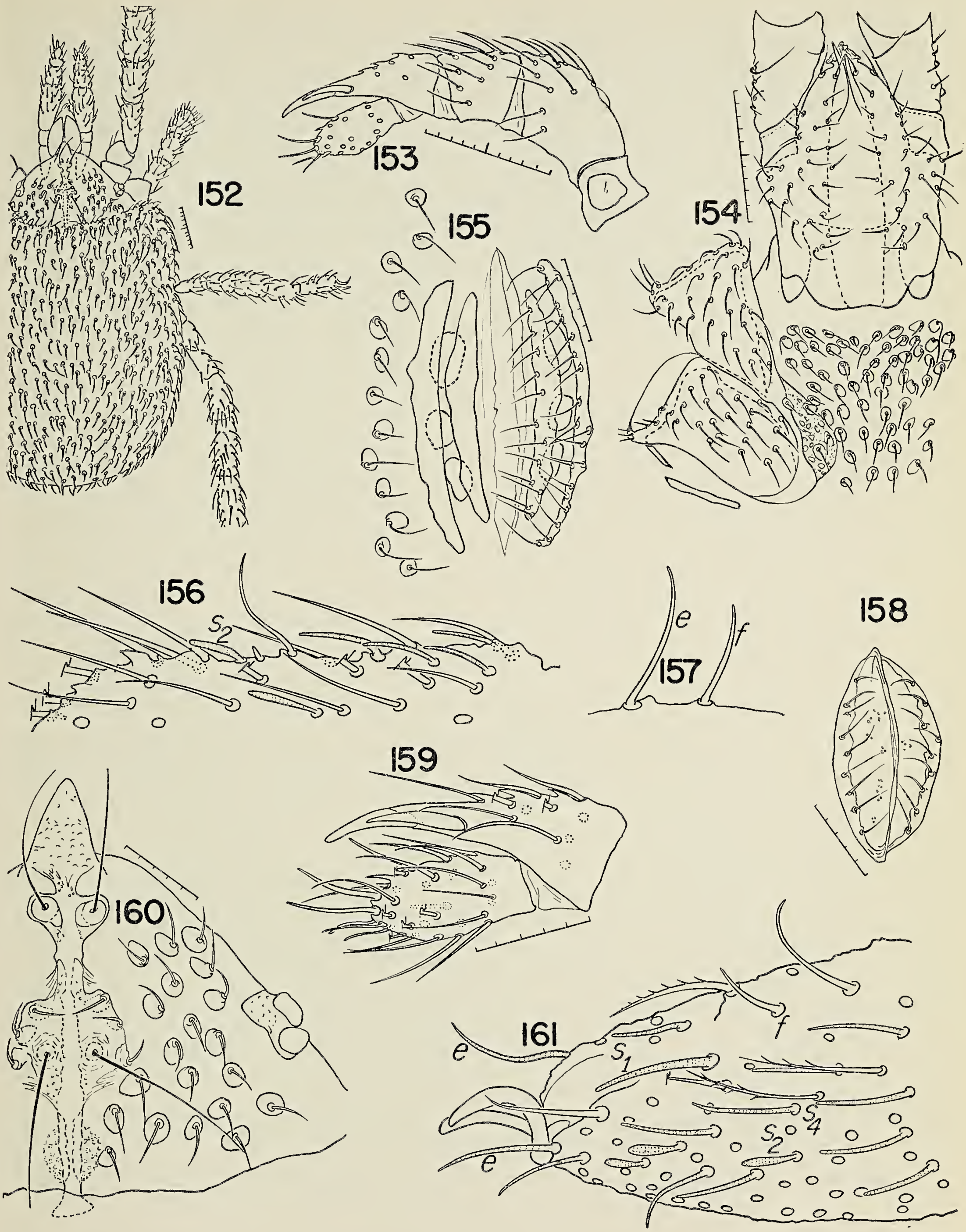
LARVA: Unknown.

TYPE LOCALITY: East fork of Hat Creek, above Hat Lake, at an elevation of about 7,250 ft., Mount Lassen, California (holotype male), under rocks and sticks along the stream in a cascade meadow. August 7, 1955, collected by the writer. Type in author's collection.

The writer wishes to express his appreciation to the National Park Service for their cooperation in these studies. As a general rule, most forms which can be collected within National Park boundaries can also be collected outside with nearly equal facility. However, three species of great interest in the present work (*D. micidium*, *Johnstoniana latiscuta*, and *Lassenia lasseni*) have been found only within the limits of Lassen Volcanic Park, despite intensive collecting at a large number of points in the Pacific coast states.

REMARKS: This species can be readily differentiated from *D. monoense* n. sp. by several characteristics. It is much smaller, the length being about 1,040 μ compared with 1,630 to 1,820 μ for *D. monoense*. There are about 20 dorsal propodosomal setae outside of the scutum, compared with fewer than 10 in most

	tr	bf	tf			pa			ti			ta					
	n	n	s_3	s_4	e	s_3	s_4	e	s_3	s_4	e	s_1	s_2	s_3	s_4	e	f
I	6	m	19	0	1	53	0	2	58	0	3	1	3	0	41	m	1
II	4,5	m	4	1	1	10	2	1	8	3	2	0	1	0	5	2	1
III	6	m	7	1	1	13	4	2	10	3	3	0	0	0	5	2	0
IV	14	m	7	3	1	17	6	3	16	5	3	0	0	0	5,6	2,3	0



FIGS. 152–161. *Diplothrombium micidium* n. sp.: 152, dorsum, female; 153, palp, anterior; 154, gnathosoma, coxae I and II, intercoxal area, female; 155, genital area, female; 156, tarsus II showing setal types, female; 157, famulus and nearby eupathid, male; 158, anus, female; 159, tibia and tarsus of palp, female, anterior; 160, propodosoma, female; 161, tarsus I, female, posterior.

specimens of *D. monoense*. The genital and paragenital sclerites of the female have considerably fewer setae than in the comparison species; also the genital sclerites of the male have 16 to 18 uniformly spaced setae, while in *D. monoense* there is a dense concentration of setae in the anterior 0.4 of the plate. Famulus$_1$ is at 0.65*d* while in *D. monoense* it is at 0.29–0.32*d*. The solenidion$_1$ of tarsus I is at 0.80*d* compared with 0.52*d* for *D. monoense*. Other differences can be found in the descriptions of the two species, or by comparison of specimens.

Diplothrombium cascadense new species

LARVA: Idiosoma (Fig. 168) 261 to 315 μ long, 189 to 225 μ wide, length/width = 1.38–1.44; average of eight specimens 288 μ by 207 μ, length/width = 1.41. Scutum (Fig. 174) with two pairs of sensilla, the posterior ones long, smooth, the anterior ones very short; otherwise with four faintly pectinate setae. A knoblike projection at the anterior end of the scutum, acuminate in normal specimens, but the point usually directed ventrally and ordinarily visible only in lateral view. This point is much better developed than in *D. monoense*. A distinct transverse line crosses the scutum behind the posterior sensilla. Crista metopica distinct. Corneae two on each side, borne on a feebly developed and protruding ocular plate. Dorsal and marginal setae about 30 in number, each borne on a platelet, shaft smooth, or with a very few fine barbs. Membranous cuticle striate.

Coxal and intercoxal chaetotaxy (Fig. 169) as in *D. monoense*. No supracoxal seta on I. Postcoxal area with only about 20 smooth setae on each side, each borne on a separate plate. Anal anlage well developed, but without sclerites.

Base of gnathosoma as described for *D. monoense;* supracoxal setae absent. Palpal trochanter fenestrated anteriorly, lacking setae (Fig. 179). Femur, patella and tibia with one, one and three slender setae respectively, tibia with large, clawlike terminal seta bifid. Palpal tarsus essentially identical with that of *D. monoense*, but smaller. All setae hemipectinate (Fig. 176). Podocephalic canals well developed.

Chaetotaxy of legs as shown in accompanying table (s = solenidia, e = eupathidia, f = famulus, n = normal setae).

Patella I with only 8 solenidia$_3$ dorsally, compared with the 15 in *D. monoense*. Tarsus I (Fig. 178) with large, procumbent solenidion$_1$ at 0.35*d*, eupathidia at 0.59*d*, and 0.89*v*, famulus displaced far anteriorly to 0.65 (the famulus in *D. monoense* is at the same level as the solenidion). Dorsal eupathid without companion seta. A group of three smooth, slender setae at 0.76, 0.80 and 0.84, as in *D. monoense;* otherwise with 29 bihemipectinate normal setae in specimen drawn. Tarsus II (Fig. 175) with short, spikelike famulus at 0.44, a solenidion at 0.47, and a eupathid at 0.86*v*. A pair of smooth, slender setae at 0.77 and 0.80; otherwise with 21 bihemipectinate normal setae.

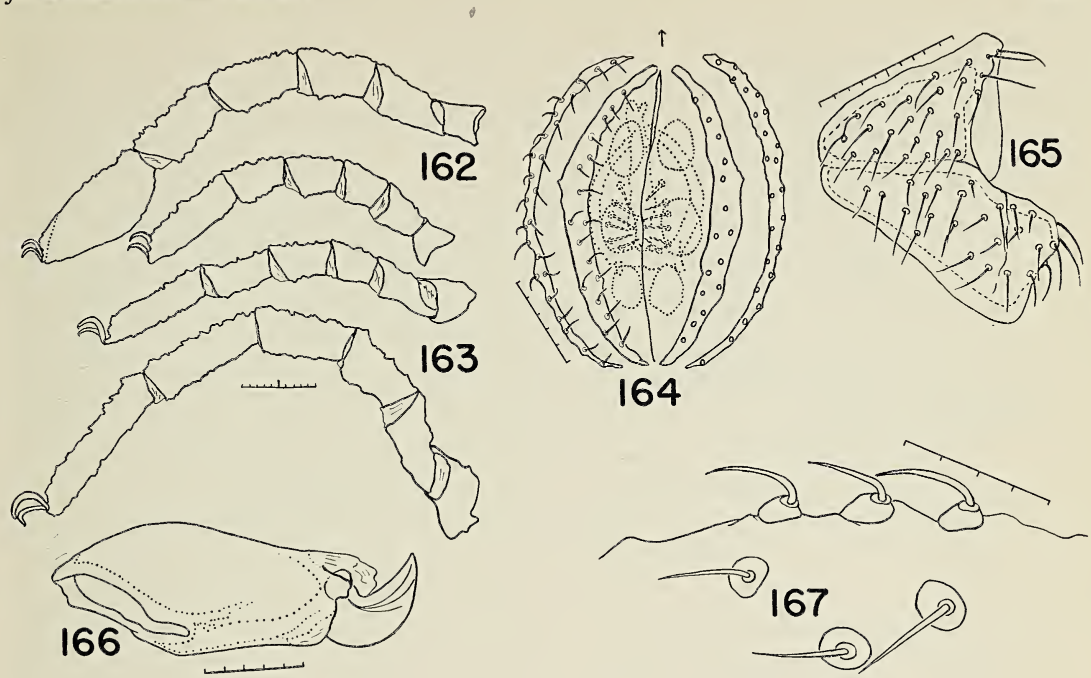
Tarsus III (Fig. 177) with a group of five smooth, slender setae lying between 0.73*d* and 0.84*v;* otherwise with 11 bihemipectinate setae. All tarsi with two smooth, unequal, scythe-shaped claws.

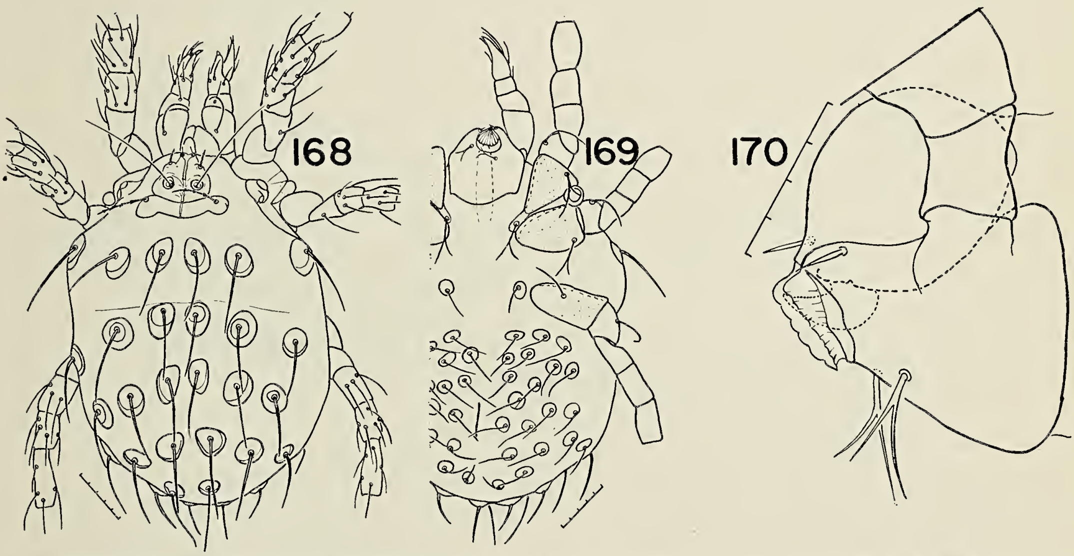
TYPE LOCALITY: Salt Creek Falls, Lane Co., Oregon. Grass and flowers (holotype larva). July 7, 1952. Collected by the writer. Type in author's collection.

REMARKS: The larva of this species differs from that of *D. monoense* in a number of significant respects. It is smaller, ranging in

CHAETOTAXY OF LEGS

	tr	bf	tf		pa		ti			ta				
	n	n	s_3	n	s_3	n	s_3	s_4	n	s_1	s_2	e	f	n
I	1	1	2	5	8	4	1	1	6	1	0	2	1	32
II	1	2	1	4	2	4	1	1	6	0	1	1	1	23
III	1	2	1	4	2	4	1	0	6	0	0	0	0	16

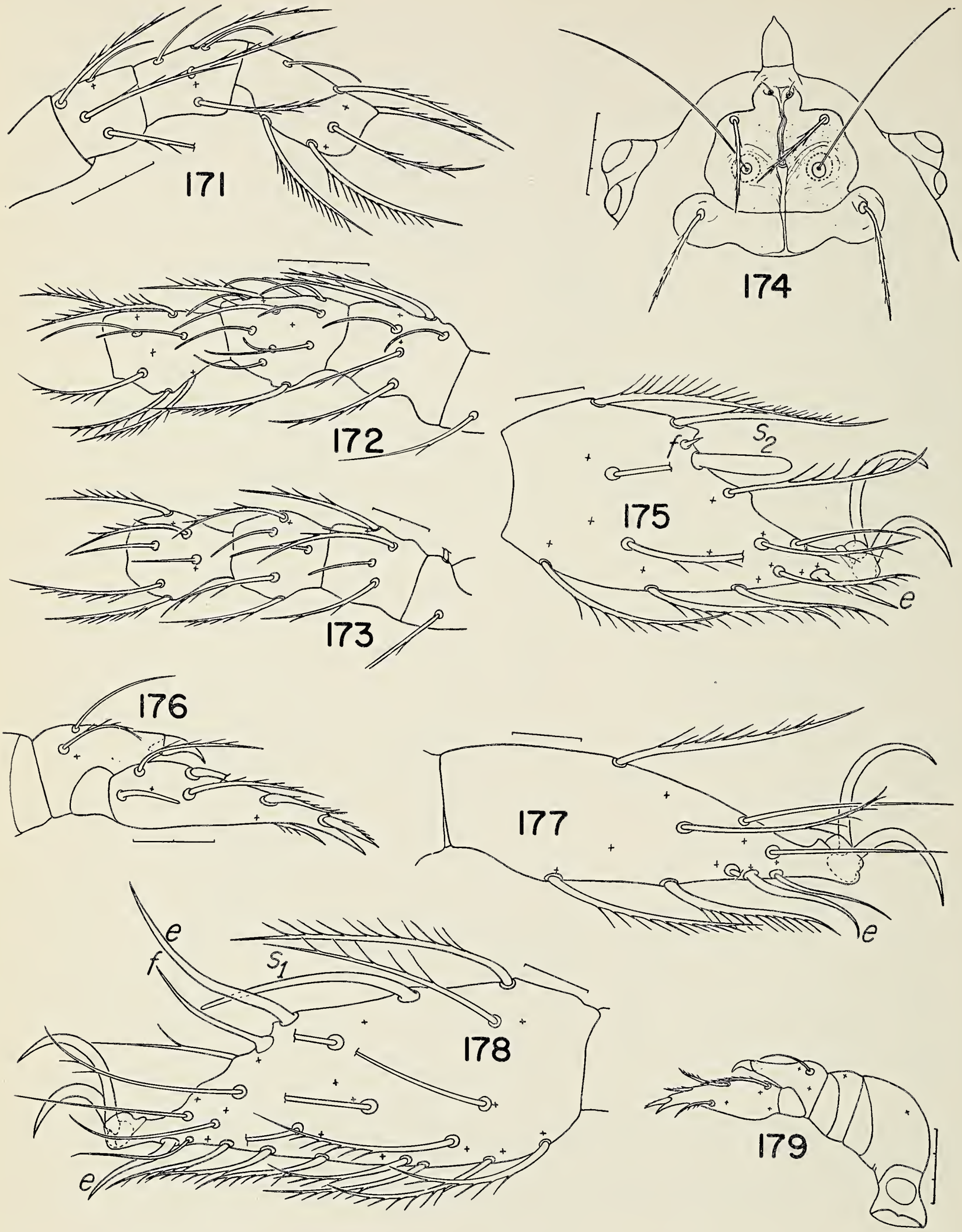




FIGS. 162–167. *Diplothrombium micidium* n. sp.: 162, legs I and II, female; 163, legs III and IV, female; 164, genital area, male; 165, coxae III and IV, female; 166, chelicera, female; 167, hysterosomal setae, female, side and top views.

FIGS. 168–170. *Diplothrombium cascadense* n. sp., larva: 168, dorsum; 169, venter; 170, gnathosoma, lateral view.

length from 261 to 315 μ (*D. m.:* 343 to 389 μ), the dorsal and ventral body setae behind the scutum and coxae number only about 50 (*D. m.:* 72–74 setae here), patella I has only 8 s_3 dorsally (*D. m.:* about 15 s_3 here), and the famulus of tarsus I is at 0.65, while the solenidion is at 0.35 (*D. m.:* famulus$_1$ and s_1 both at about 0.43). Other differences can be



FIGS. 171–179. *Diplothrombium cascadense* n. sp., larva: 171, leg III, telofemur to tibia; 172, leg I, telofemur to tibia; 173, leg II, telofemur to tibia; 174, propodosoma; 175, tarsus II, posterior; 176, tibia and tarsus of palp, posterior; 177, tarsus III, posterior (the smooth seta at 0.74*v* is a normal seta); 178, tarsus I, posterior; 179, entire palp, anterior.

found in the descriptions of the two forms.

No adult of this species was found, despite extensive collections made at the type locality.

Diplothrombium longipalpe Berlese 1887

There is little in the original description of this species which can be relied upon to distinguish critically between this form and the two species described here by the writer. The basal prominence of tarsus I appears to be significantly closer to the base of the segment than in *D. monoense*, but a similar prominence is found in approximately the same position in *D. micidium*. It is probable however that direct comparison of *D. micidium* and *D. longipalpe* would reveal reliable specific differences. Berlese regarded the form named just below as a variety of *D. longipalpe*, but it is likely that if the differences Berlese noted were real that there are two distinct species. A complete bibliography of the species was given by Thor and Willmann (1947, p. 223).

Diplothrombium septentrionale
Berlese 1912, new combination

This form was considered a variety of *D. longipalpe*, but it is almost certainly a distinct species. Again, the information available on this species in the literature is totally inadequate to make any critical comparisons with the two new forms described in the present paper.

Diplothrombium misellum Berlese 1918

Berlese provided no figure of this species, but judging from his description (a single area sensilligera, anterior setae spiniform) this is not a *Diplothrombium* but probably a *Centrotrombidium*. Hence, it is provisionally placed in that genus, *q.v.*

LASSENIINAE new subfamily

DIAGNOSIS: Adults with anterior sensilla greatly reduced or of markedly different form from posterior sensilla. Pregenital tubercle present. Supracoxal setae present on coxa I and gnathosoma in both larva and adult. Larvae with anal sclerites. Deutorostral setae present; terminal seta of palp eupathidiform. Tarsi each with three claws.

REMARKS: To each of the above statements should be added "in known forms." The group will have to be redefined as it becomes better known.

Lassenia new genus

ADULTS: Rather large mites, the known species between 1,000 and 1,700 μ in length, dark brown to brownish red. Scutum large, expanded, several times wider than the width of the crista metopica. Posterior sensilla elongate, slender; anterior sensilla variable in form, resembling the rest of the setae on the scutum so that they are sometimes not readily discernible. Ocular plates bicorneate, protruding, but not stalked. Dorsal setae of hysterosoma simple, smooth, stiff, rodlike in the known species, all of same type. Pars medialis of coxa I either present or absent. Coxal rings I and II both membranous dorsally, coxa I with supracoxal seta. Genital opening with three pairs of acetabula, guarded by a pair of crescentic genital sclerites and a pair of paragenital sclerites; a hemispherical or pedunculate sclerite immediately anterior to the genital opening. Anal sclerites present. A characteristic *Lassenia*-organ anterior to coxa III. Base of gnathosoma with or without setae; supracoxal setae present. Proto-, deuto-, and tritorostral setae all present. Velum simple. Chelicerae slightly to noticeably deflexed posteriorly. Palpi with five free segments, distal margin of trochanter deeply incised on anterior surface. Palpal tibia with heavy terminal seta, at the base of which is a single stout seta. Tarsus of palp with a single solenidion on posterior aspect which may be in either the basal or the distal half of the segment; distal half of the tarsus richly supplied with eupathidia. Eupathidia present on all

segments of all legs beyond the basifemur, sometimes present on ventral surface of telofemur, patella and tibia I. Vestigial setae present on patella I and II and tibia I, but absent on tibia II. Solenidia$_1$, s_2 and s_4 generally indistinguishable, so that in effect only two solenidial types are present on the legs. All tarsi essentially lacking claw fossa; IV without a posterior eupathid in terminal 1/10th of segment.

LARVA: Parasitic upon Diptera living in subaquatic environments. Scutum of known species with a pair of long posterior, and a pair of shorter anterior sensilla, plus two pairs of other setae near the anterolateral and posterolateral corners of plate; anterior sensilla sometimes set off on a minute sclerite separate from the rest of the scutum. Crista absent. Dorsal setae variable in number, borne on individual setigerous sclerites. Ocular plates bicorneate. Coxae I with two pairs of setae, II with one or two pairs of setae, and III with two or three pairs of setae; a well-developed *Lassenia*-organ anterior to coxa III. Urpore present. Anal sclerites with two pairs of setae in known species. Base of gnathosoma with only the supracoxal setae, rostrum with protorostral, deutorostral and tritorostral setae present and well developed. Palpi somewhat geniculate, femur considerably heavier than rest of segments, and sometimes incompletely separated from patella. Tibia with heavy unidentate or bidentate seta at tip. Tarsus of palp elongate, cylindrical, with a single solenidion posteriorly, a terminal and subterminal eupathid. Femur of legs undivided, legs with only five free segments beyond the coxae. Vestigial setae present on patella I, II, and tibia I, but absent from tibia II. Tibia I with two types of solenidia, s_3 and s_4, the latter larger than the former, with distinct internal structure, and a basal companion seta. Solenidion$_1$ also with a basal companion seta, s_2 without a companion seta. Dorsal eupathid of tarsi I and II with a basal companion seta. All tarsi tridactyl, the median claw considerably longer, more slender, and erect than the lateral claws.

TYPE SPECIES: *Lassenia lasseni* new species.

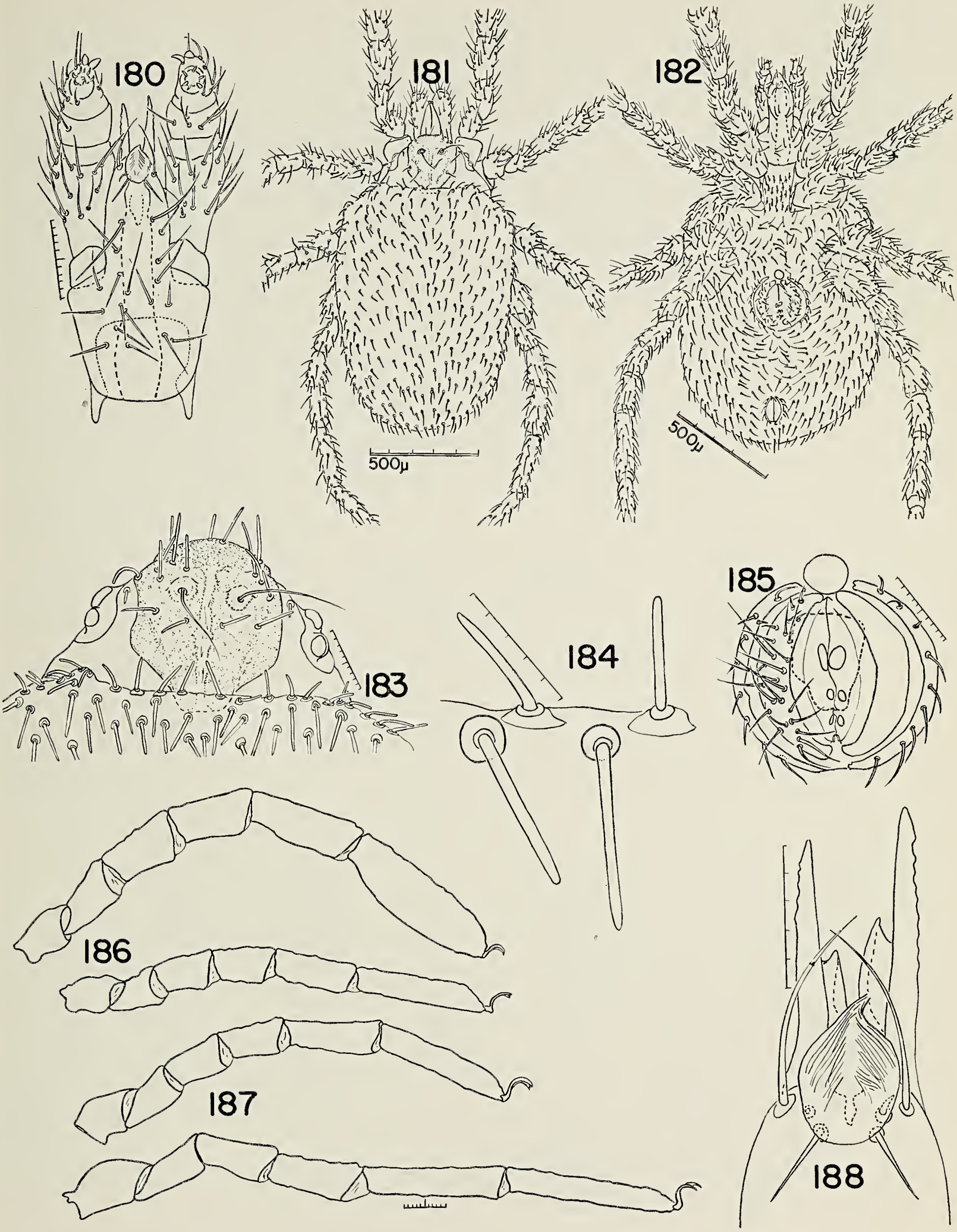
REMARKS: The forms described under this genus have many features in common, but there are also a few in which they differ markedly. It is possible that these may eventually necessitate the creation of a discrete genus for *L. spinifera*, although at present this does not seem necessary.

For a while it was felt that this genus and *Polydiscia* Methlagl 1928 might be identical. Judging from the original description of the latter genus, this might be so, but the possibility is sufficiently remote to make a final decision unwarranted until *Polydiscia squamata* has been fully described.

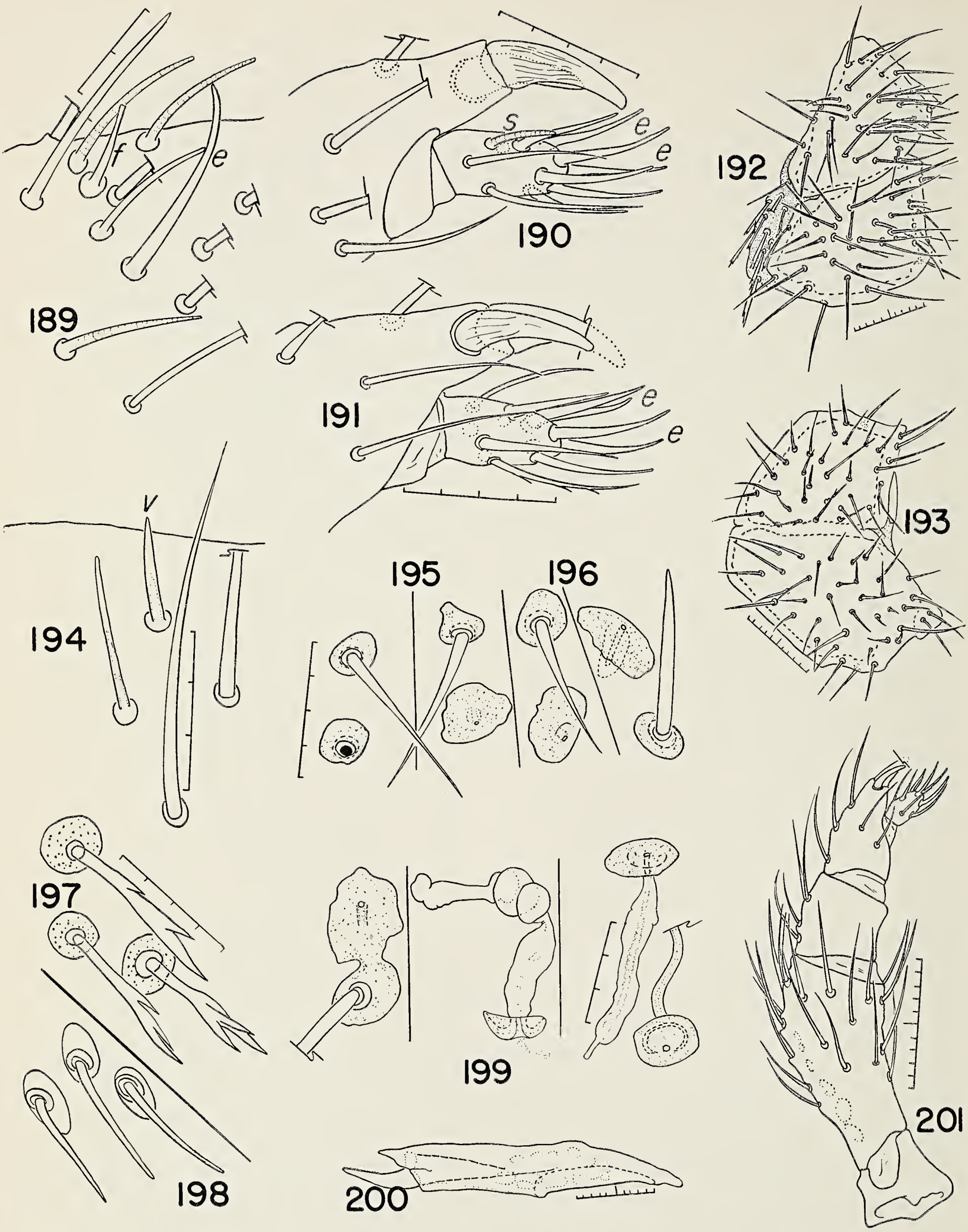
Lassenia lasseni new species

MALE: Body (Fig. 181) 1,534 to 1,716 μ long to tip of propodosoma, 936 to 1,144 μ wide, length/width = 1.44–1.64; average of five specimens 1,628 μ long, 1,066 μ wide, length/width = 1.53. Scutum (Fig. 183) broad, truncate posteriorly, rounded anteriorly, with a single pair of very slender smooth sensilla arising from coarse alveoli. Otherwise with seven to nine stiff, stout, setae on either side of the mid-line; these setae slightly fusiform and smooth. Crista metopica well developed, extending from posterior margin to a point a little more than half way between the alveoli of the sensilla and the anterior margin of the plate. Cuticle of scutum coarsely punctate except for the pale posterolateral portion of the plate. With the exception of the sensilla all of the setae of the scutum are of the same type. Ocular plates well developed and bearing two corneae, the anterior one the larger of the two. A single seta arising from a very minute sclerite between the ocular plate and the scutum; otherwise dorsum of propodosoma devoid of setae. Dorsal body setae (Fig. 184) stiff, smooth, straight, each arising from a small sclerite. Cuticle of dorsum smooth, without striae.

Coxa I (Fig. 192) with 45 to 50 smooth, slender setae plus the short, blunt, spikelike supra-



FIGS. 180–188. *Lassenia lasseni* n. sp., male: 180, gnathosoma, ventral; 181, dorsum; 182, venter; 183, propodosoma; 184, dorsal hysterosomal setae; 185, genital area; 186, legs I and II; 187, legs III and IV; 188, tip of rostrum, ventral.



FIGS. 189–201. *Lassenia lasseni* n. sp.: 189, specialized setae of tarsus I, male; 190, tibia and tarsus of palp, male, posterior; 191, tibia and tarsus of palp, male, anterior; 192, coxae I and II, male; 193, coxae III and IV, male; 194, vestigial and other setae of tibia I, male; 195, *Lassenia*-organ of right and left sides of same male; 196, same, a different male; 197, intercoxal setae, male; 198, ventral hysterosomal setae; 199, *Lassenia*-organ, female; 200, Chelicera, male; 201, palp, male, anterior.

coxal seta; II with 40 to 45 setae. Dorsal portion of both coxae I and II membranous. Pars medialis coxae with 8 to 10 setae, outside of which are 20 to 25 setae in the intercoxal area. All of these plus a very few of the most medial setae of the coxae are two- to four-pronged, and quite stiff (Fig. 197). Apodemes behind II lying in a portion of the cuticle devoid of setae. Just anterior to III is the homologue of the unusual sclerite in the same position in the larva. It is extremely variable in form, but its constancy indicates that it is an important structure. In most cases it appears to be a plate with a gland opening. It is also present in the female. Coxae III and IV with about 40 setae each, all but one or two of which are slender, smooth and tapering; the remaining one or two are faintly barbed (Fig. 193). Cuticle of coxae brown in color, minutely and densely punctate. Genital sclerites (Fig. 185) forming a nearly hemispherical protuberance on the ventral surface of the body; deeply pigmented, each bearing about 24 smooth, slender setae. Paragenital sclerites slender, crescentic, each bearing 7 setae of the same form as those on the genital sclerites. Between the anterior ends of the paragenital sclerites is a hemispherical, deeply pigmented bulla. All sclerites associated with the genital opening minutely punctate. Three pairs of genital acetabula present; penis scarcely more than half the length of the genital sclerites. Anal sclerites well developed but slender, each bearing zero to five smooth setae. Most ventral setae much more slender and tapering than those on dorsum, each borne on a separate minute sclerite. Setae between coxae III of right and left sides of much the same form as those between coxae II, but not quite so heavy (Fig. 198).

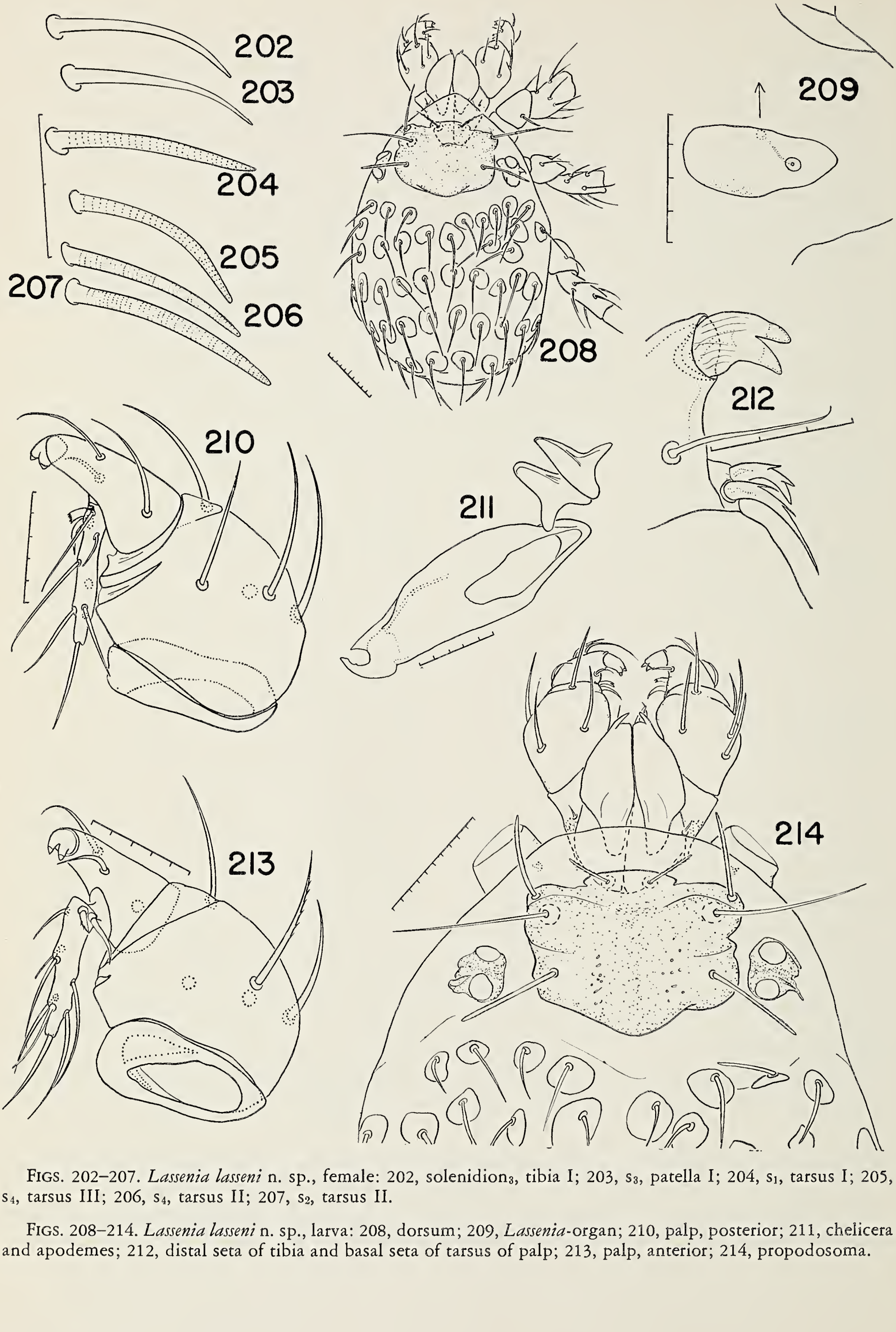
Base of gnathosoma with 12 to 15 smooth slender setae (Fig. 180), rostrum with 7 or 8 more in addition to those at the end of the rostrum. Supracoxal setae rather long (20 to 25 μ), tapering to a sharp point, inserted in the soft membranous dorsal cuticle of the coxae. Velum appearing elliptical in ventral view, inner margin fimbriated. Lateral to the velum is a pair of longer slender protorostral setae directed anteriorly, while just above the posterolateral margin of the velum is a pair of small spikelike deutorostral setae and a longer pair of tritorostral setae oriented in a posteroventral direction (Fig. 188).

Chelicerae (Fig. 200) relatively long and slender, heavily sclerotized, cuticle densely punctate; tarsus with 14 to 15 very minute teeth visible under high magnifications; cheliceral membrane pointed, extending to about middle of tarsus. Palpi (Fig. 201) relatively long, slender, straight. Trochanter devoid of setae, anterior aspect fenestrated. Femur with 29 to 30 setae, patella with 9 to 10 setae, anterior surface bare; tibia with about 10 normal setae plus the heavy spiniform terminal and subterminal setae. Tarsus (Figs. 190, 191) with an annulate solenidion at 0.4 to 0.5*pd*, six to eight large eupathidia on distal half of segment and two to six normal setae (quite variable). All normal setae of palp appearing smooth at low magnification (100 x), but at higher magnifications a few very minute barbs can be seen on some of the setae. No tracheal openings could be seen on the dorsum of the gnathosoma in the position normally occupied by these, and no tracheae could be seen internally.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, n = normal setae, m = many).

Eupathidia present dorsally or marginally

	tf	pa			ti				ta					
	e	s_3	e	v	s_3	s_4	e	v	s_1	s_4	s_2	s_3	e	f
I	2	7	4	1	27	0?	5,7	1	(——m——)			0	m	1
II	1	4	3	1	10	1	2	0	(–13–)		1	0	4	1
III	1	5	2	0	10	0	1	0	0	8	0	0	3	0
IV	1	6	2	0	8	0	1	0	0	10	0	0	3	0



FIGS. 202–207. *Lassenia lasseni* n. sp., female: 202, solenidion$_3$, tibia I; 203, s_3, patella I; 204, s_1, tarsus I; 205, s_4, tarsus III; 206, s_4, tarsus II; 207, s_2, tarsus II.

FIGS. 208–214. *Lassenia lasseni* n. sp., larva: 208, dorsum; 209, *Lassenia*-organ; 210, palp, posterior; 211, chelicera and apodemes; 212, distal seta of tibia and basal seta of tarsus of palp; 213, palp, anterior; 214, propodosoma.

on all segments of all legs beyond the basifemur, none ventral, except on the tarsi. Vestigial setae present only on patella I and II and tibia I. Famulus of tarsus I at 0.55*pd*, $famulus_2$ at 0.62 to 0.79 (this variation was noted on the right and left sides of a single male). Eupathidia of tarsus I extending from 0.17*v* to 0.17*d*, claw fossa absent. Eupathidia of tarsus II extending from 0.43*d* to 0.97*v*; tarsus tapering rapidly beyond 0.75*d*, but no true claw fossa present. Tarsus III with eupathidia at 0.41*d*, 0.64*p*, and 0.96*pv*; IV with eupathidia at 0.43*d*, 0.48*d*, and 0.67*p*, none near end of tarsus. Solenidia of tarsi difficult to interpret because of convergence in form, especially between types s_1, s_2, and s_4. No solenidia referable to type s_3 found on the tarsi. Tarsus II with a somewhat heavier solenidion, presumably s_2, at 0.47*d*, plus about 12 others presumably s_1 or s_4 or both. Claws of all tarsi simple, smooth, scythe-shaped.

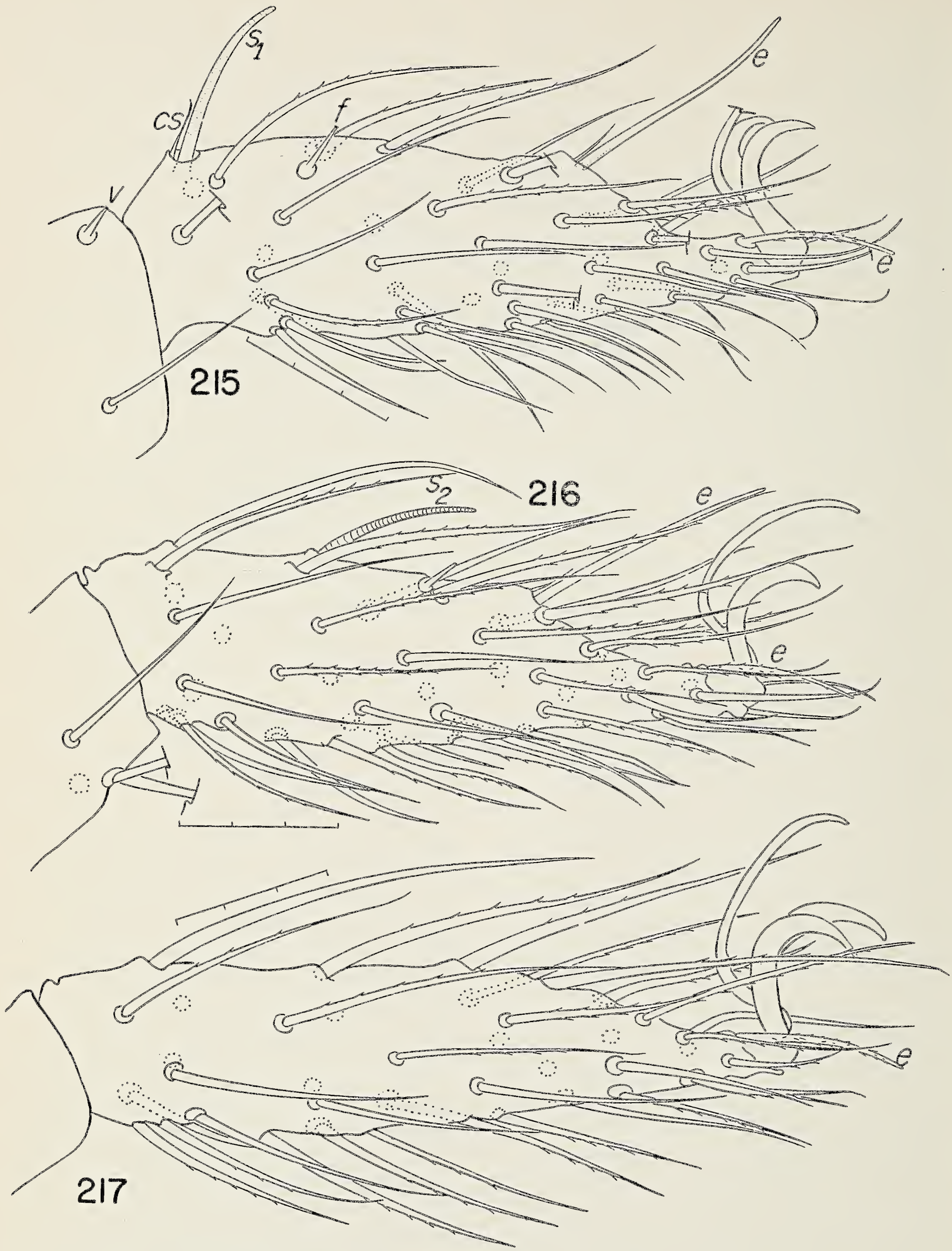
FEMALE: Body 1,378 to 2,574 μ long, 806 to 1,872 μ wide, length/width = 1.38 to 1.71; average of six specimens 1,846 μ long, 1,235 μ wide, length/width = 1.50. Resembling the male in virtually all respects, even the genital sclerites and paragenital sclerites being only slightly larger and with possibly a very few more setae than in the male. Genital acetabula distinct, the anterior pair the largest. Anal sclerites also as in male.

LARVA: Body (Fig. 208) 522 to 576 μ long in partially engorged specimens. Scutum (Fig. 214) with anterior sensilla short, stiff and faintly pectinate; posterior sensilla very long, slender, smooth, uniformly tapered. Setae at anterolateral and posterolateral angles of scutum stiff, faintly roughened. Ocular plates with two distinct corneae. Cuticle of ocular plates and of scutum faintly punctate. Crista metopica completely absent. With 48 to 53 dorsal and marginal setae each borne on individual sclerites in the two specimens examined; lateral setae more slender than the others. Cuticle of dorsum without striae.

Coxae I and II with two setae each, III with three (occasionally four) simple smooth setae; intercoxal area completely devoid of setae. Coxae I and II close together, urpore well developed; a structure of unknown nature (the "*Lassenia* organ," Fig. 209) laterally between II and III. Under oil immersion this appears to be a plate of much the same form as the setigerous sclerites, with the cuticle faintly punctate, and with an alveoluslike structure on the inner half of the plate. Near the center of this alveoluslike structure is a minute pore about 0.9 μ in diameter, which opens into a delicate chitinous duct about 22 μ long. At its inner end this duct expands to form a delicate cup or sphere approximately 3.6 μ in diameter. The duct is not hydrolyzed by the enzymes used to clear the mites.

Supracoxal setae present in the membranous dorsal portion of coxa I, but absent on II and III. Postcoxal area with 23 to 27 setae exclusive of those borne on the anal sclerites, all of these setae arising from individual feebly developed sclerites with faintly punctate cuticle (Fig. 221). Anal sclerites moderately developed, with two to three pairs of setae.

Base of gnathosoma (Fig. 229) devoid of setae, cuticle densely and minutely punctate, posterior half partly divided by vertical chitinous septum. Protorostral and tritorostral setae long and slender, deutorostral setae short and spikelike, posterorostral setae absent. Supracoxal setae rather long and uniformly tapered. Velum very delicate, semicircular in form, consisting of a fimbria of extremely delicate chitinous processes extending inward toward the mid-line at the tip of the rostrum. Chelicerae (Fig. 211) with digitus mobilis a soft membranous process, tarsus with distal portion slender, scythe-shaped, of fairly uniform thickness throughout most of length, and typically with two small teeth near the end of the tarsus. Trochanter of palp (Figs. 210, 213) very short, ringlike, lacking setae. Femur greatly swollen and bearing five smooth setae on dorsal and posterior aspects. Patella incompletely separated from femur posteriorly (Fig. 210); with a single dorsal



FIGS. 215–217. *Lassenia lasseni* n. sp., larva: 215, tarsus I, posterior; 216, tarsus II, posterior; 217, tarsus III, posterior.

seta. Distal portion of tibia curved sharply toward median line (Fig. 214); three pairs of smooth normal setae plus the greatly enlarged bifid distal seta. The latter is marked with somewhat irregular longitudinal striae (oil immersion, Fig. 212) and the two teeth are hollow in the distal half. Tarsus with two strongly curved, usually barbed heavy setae at base, a solenidion at 0.25 to 0.33*p*, one terminal and one subterminal eupathid; otherwise with five smooth, normal setae. Podocephalic canals reaching from cheliceral apodemes to, or nearly to, the urpore; a number of branches present.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathida, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Femora I to III undivided (Figs. 218–220). Patella I and II with a vestigial seta dorsally. Tibiae with vestigial seta present only on I but with numerous solenidia dorsally as shown in the accompanying table; normal setae also abundant. Solenidion$_4$ on tibia I is longer, larger, and different in structure from the solenidia$_3$; moreover it has a companion seta at the base. Tarsus I with s_1 at 0.08 to 0.10*d* and a large eupathid at 0.64 to 0.69*d*, each with a companion seta; famulus at 0.24 to 0.27*pd* and a second eupathid at 0.91*pd*. The famulus is borne on a vesicular alveolus and is flattened and expanded at the tip (Fig. 228). Tarsus II with a delicately annulate solenidion at 0.34 and a eupathid with companion seta at 0.65*d*. Famulus like that on I but at 0.49*pd*; a second eupathid at 0.90*pd*. Tarsus III with a single eupathid at 0.91*pd* but with no other specialized setae. Most of the normal setae of the legs are delicately pectinate. All tarsi with three claws, the median one longer and more slender than the lateral ones.

TYPE LOCALITY: Mount Lassen, California, in a small cascade stream about one mile above Hat Lake; elevation about 7,250 feet (holotype male). July 9, 1954, and August 7, 1955. I. M. Newell, collector. Also collected at headwaters of Kings Creek, Mt. Lassen, California, August 6, 1955, by the writer.

REMARKS: This species can be differentiated from *L. scutellata*, new species, by the much larger number of setigerous sclerites on the dorsum (*L. scutellata:* only about 20 dorsal and marginal setae), the bifid form of the terminal seta of the palpal tibia (*L.s.:* this seta not bifid), and by numerous points of difference in the chaetotaxy of the legs which will be apparent by a comparison of the tables and descriptions given for the two species.

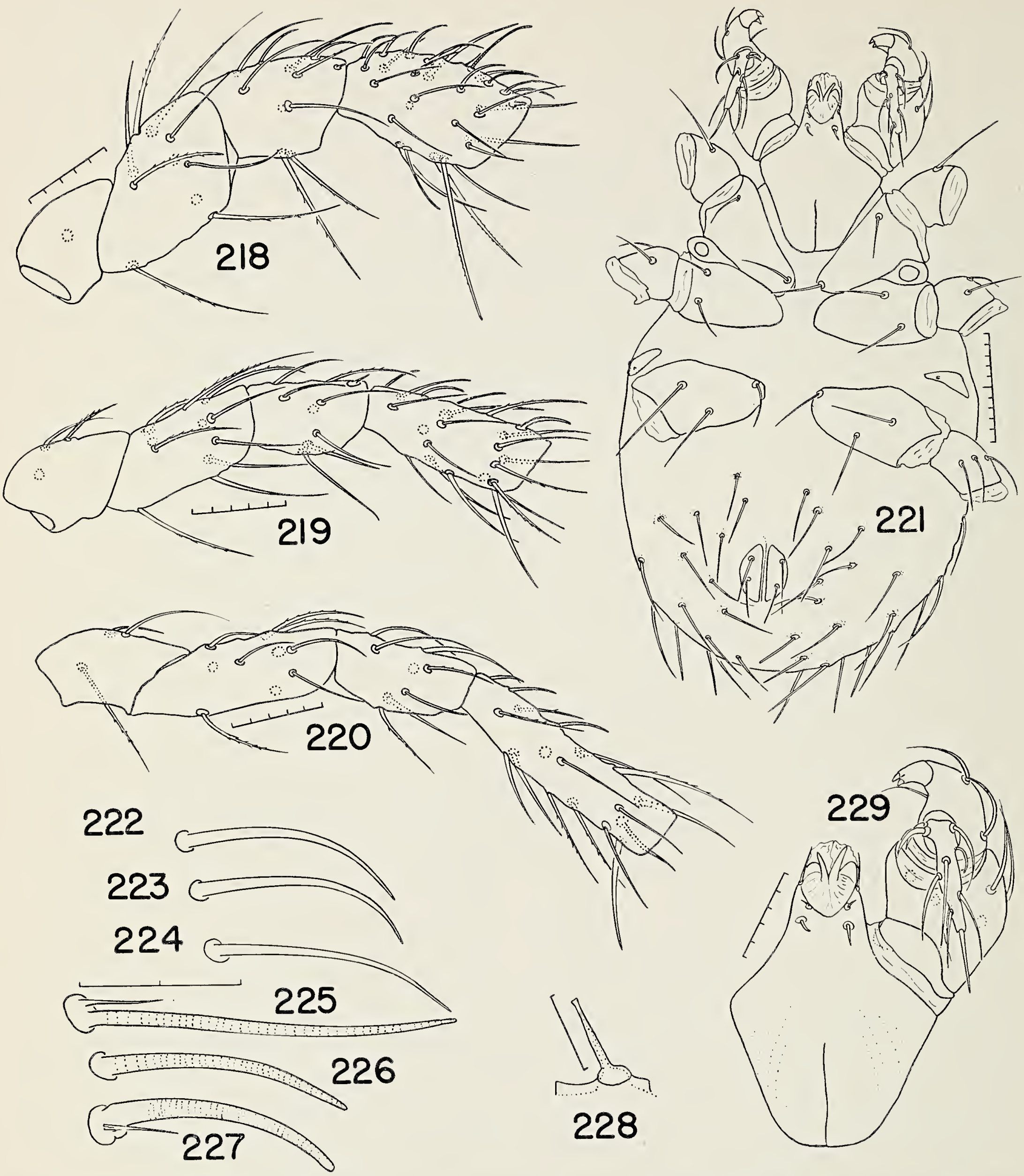
Lassenia lasseni is definitely a cold-stenothermal species and its distribution is undoubtedly limited by this fact. The larvae are parasitic upon small species of Diptera resembling Drosophilidae, found breeding along the banks of mountain streams. They are of the self-detaching type.

The correlation between the larva and adult of this species has been established solely on the basis of their occurrence at the same locality. While the correlation is to a certain degree provisional, it is reasonably certain that the two forms are conspecific. In all, 9 larvae, 6 nymphs, and 25 adults were collected at this location, and there is no indication that more than one species is involved in the collection. The species is not as common as the above numbers might indicate, for this represents the total catch of about 15 hours of hand collecting over a three-day interval. The adult was first collected July 9, 1954, and larvae and adults were found August 7, 1955.

Lassenia spinifera new species

FEMALE: Two specimens available for study

	tr	fe	pa			ti					ta					
	n	n	s_3	v	n	s_3	s_4	v	c	n	s_1	s_2	e	f	c	n
I	1	10	2,3	1	8	12	1	1	1	16	1	0	2	1	2	50
II	3	10–12	0	1	8	4,5	0	0	0	17	0	1	2	1	1	43
III	3.4	9.10	0	0	8	3	0	0	0	15	0	0	1	0	0	40



FIGS. 218–229. *Lassenia lasseni* n. sp., larva: 218, leg I, trochanter to tibia; 219, leg II, trochanter to tibia; 220, leg III, trochanter to tibia; 221, venter; 222, solenidion$_3$, tibia I; 223, s$_3$, patella I; 224, s$_3$, tibia III; 225, s$_4$, tibia I; 226, s$_2$, tarsus II; 227, s$_1$, tarsus I; 228, famulus$_1$, tarsus I; 229, gnathosoma.

measured 1,326 and 1,794 μ to tip of scutum, 637 μ to 832 μ wide (length/width 2.08, 2.16). The smaller specimen was evidently an immature female and even the larger one was nonovigerous. Scutum (Fig. 232) much more elongate than in the type species of the genus, and with a distinct anterior spine (hence the name). A pair of very elongate, slender,

smooth sensilla at or slightly behind the middle of the plate and a pair of much shorter setae near the base of the spine. These are of the same general form as the other setae of the dorsum of the propodosoma, but their position and orientation indicate that they are the anterior sensilla. Their alveoli are indistinct and very small in contrast with those of the other dorsal propodosomal setae which are well formed. Limit of scutum indistinct in anterolateral portions where it is all but impossible to trace in undissected specimens. Crista metopica well developed up to a point about half way between the posterior and anterior pairs of sensilla. Ocular plates elongate, bearing two pairs of prominent corneae, the posterior of which are the larger. In addition to the sensilla, the dorsum of the propodosoma bears 23 to 37 smooth, slender tapering setae on each side, 8 to 15 of which are definitely outside the scutum and 13 to 20 are definitely inside the scutum; one to three setae near the anterolateral margins of the scutum of uncertain position. Dorsal hysterosomal setae markedly different from those of the propodosoma, resembling those of *Lassenia lasseni*, stiff, rodlike, each borne on a small sclerite visible under high magnification (Fig. 246). The sclerites are not noticeably elevated. Membranous cuticle of hysterosoma completely smooth.

Coxae I with 65 to 75 smooth setae each (Fig. 234) plus the short peglike supracoxal seta in the membranous portion of the dorsal surface of the coxa. Coxa II with 35 to 50 setae; dorsal wall of distal part of coxa not sclerotized, but membranous like I. Both coxae I and II devoid of setae on their medial aspects. Intercoxal area with about 70 to 75 long stiff setae arranged in a rather characteristic radiating pattern; pars medialis coxae completely absent. Behind the sclerotized part of coxa II is a single to triple row of setae like those on the coxae, behind which is the usual transverse band of membranous cuticle devoid of setae. The presence of setae in the membranous area directly behind coxa II, and the absence of the pars medialis coxae indicate a considerable reduction in the degree of sclerotization of the coxae of this species. While the specimen studied was not a completely matured female, it seems probable that the conditions described above would be found in ovigerous females also. Coxae III with 30 to 36 setae, IV with 65 to 75 setae (Fig. 244). Genital sclerites moderately well developed but not of the strongly crescentic form found in *Lassenia lasseni*, bearing 21 or 22 setae in a single to double row (Fig. 233). Paragenital sclerites very feebly developed, scarcely visible at low magnification, but at higher magnifications apparent as a slight change in texture of the cuticle; each sclerite bearing 12 to 15 setae. Anterior to the genital opening is the characteristic bulliform structure found also in the type species of the genus, and just anterior to this is a very small, transverse sclerite. Three pairs of genital acetabula present. The ventral body setae surrounding the genital opening are largely oriented in the direction of the genital opening, while the setae on the genital and paragenital sclerites are mostly oriented in a more ventrad direction. Anus (Fig. 240) completely terminal, anal sclerites fairly well delimited, weakly crescentic, bearing 16 to 17 setae each. Ventral hysterosomal setae borne on minute sclerites; shaft of seta considerably more slender and tapering than in the case of the dorsal setae, the two types intergrading laterally. Ventral cuticle mostly smooth, with only scattered traces of striations. Two small apodemes in the transverse strip of cuticle behind each coxa II. No trace of the characteristic gland found anterior to coxae III in the adults of *Lassenia lasseni* was seen in this species, but the material was not entirely favorable for study of this feature.

Base of gnathosoma (Fig. 248) totally devoid of setae, except for the supracoxals. Rostrum with four pairs of setae as shown in Figure 235. Deutorostral setae short and peglike, concealed behind the margin of the velum in ventral view. The lateral arms of the

gnathosoma are quite elongate. Chelicerae (Figs. 245, 247) with posterior end bent rather sharply downward; tarsus with about four dorsal teeth in distal half, and four to five subdorsal teeth in basal half. Palpi (Fig. 242) considerably larger and relatively thicker than in *Lassenia lasseni* (Fig. 201). Anterior aspect of trochanter deeply dissected, but the sclerotization of the femur extends deep into this, so that the fenestration of the anterior wall of the trochanter is markedly reduced; left trochanter of holotype female with, right trochanter without, a seta on posterior aspect. Femur with 51, patella 36, and tibia with 27 smooth slender setae in the single specimen studied, plus the large terminal and smaller subterminal spiniform setae on the tibia. The terminal seta of the tibia is unidentate. Tarsus (Fig. 238) with a single solenidion at 0.88*pd*, this showing faint spiral structure and a somewhat swollen base. Proximal two-thirds of tarsus with 24 normal setae like those on the other segments of the palp; distal one-third of tarsus with 15 eupathidia showing distinct annulate structure internally. The eupathidia are somewhat heavier than the solenidion, and the curvature of the two types of setae is reversed.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, n = normal setae, m = many).

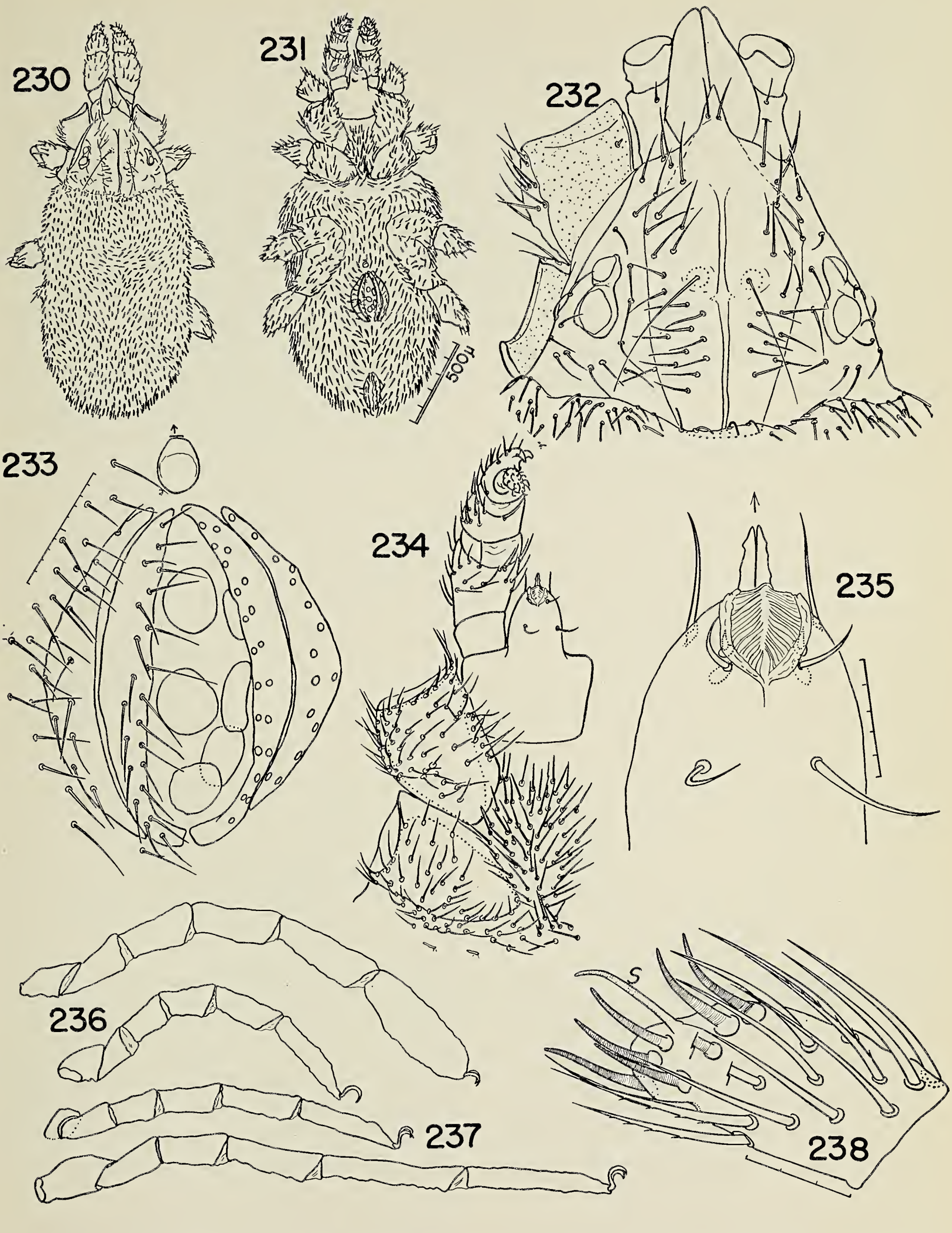
All solenidia of patella and tibia of all legs of s_3 type, except for one questionable s_4 on tibia I and II. Tarsus I with famulus at 0.80*pd* and many eupathidia extending from 0.13*v* to 0.17*d;* six or seven s_3 near the base of the tarsus, but all of the other many solenidia are more or less of the same form and size, so that it is impossible to differentiate the types with certainty. End of tarsus I rather abruptly cut off, beginning at about 0.90*pd;* claw fossa absent. Tarsus II with famulus at 0.67*pd*, and about five eupathidia between 0.17*d* and 0.97*pv;* no ventral eupathidia. One seemingly distinct s_2 at 0.36*d*, one or two s_3 near the base of the tarsus, and two or three other solenidia of indeterminable type (s_1 or s_4). Tarsus II tapering rather abruptly from about 0.67*d* to the end of the segment, claw fossa absent. Tarsi III and IV each with about five s_3 or s_4; III with five eupathidia ranging from 0.19*d* to 0.95*v*, IV with an equal number ranging from 0.18*d* to 0.79*v*, terminal eupathid lacking. All tarsi with two heavy claws faintly hirsute along convex margin.

Telofemora well supplied with eupathids especially on I. Telofemur, patella, and tibia I notable in that the majority of the eupathidia are ventral in position. Of the 10 counted on telofemur I, 6 were dorsal or marginal in position, while 4 were ventral; of the 18 counted on patella I, 6 were dorsal or marginal while 12 were ventral; and of the 32 on tibia I only 8 were dorsal or marginal in position while 24 were ventral. These figures, like the rest of the figures in the accompanying table were based on counts made on a single specimen. Vestigial setae only on patella I and II and on tibia I; no vestigial seta on tibia II. All eupathidia on the telofemur, patella, and tibia of legs II to IV either dorsal or marginal in position, none ventral.

Lassenia scutellata new species

LARVA: Body (Fig. 249) 387 μ long, 243 μ wide, length/width 1.58 (one specimen only). Scutum subrectangular in form, divided into a small anterior portion bearing the anterior sensilla, and a much larger posterior portion bearing the posterior sensilla and other setae.

	tf	pa			ti				ta					
	e	s_3	e	v	s_3	s_4	e	v	s_2	s_1	s_4	s_3	e	f
I	10	13	18	1	54	1?	32	1	(——m——)			7±	m	1
II	3	7	4	1	8	1?	6	0	1	(–2,3–)		1,2	5	1
III	2	7	6	0	9	0	5	0	0	0	(–4,6–)		5	0
IV	1	8	8	0	17	0	6	0	0	0	(–4,6–)		6	0



Figs. 230–238. *Lassenia spinifera* n. sp., female: 230, dorsum; 231, venter; 232, propodosoma; 233, genital area; 234, gnathosoma, coxae I and II, and intercoxal area; 235, tip of rostrum; 236, legs I and II; 237, legs III and IV; 238, tarsus of palp, posterior.

Cuticle of scutum slightly punctate; crista absent. Anterior sensilla only about half as long as posterior sensilla; scutum otherwise with two other pairs of setae. All setae of scutum with a few very minute barbs visible only under high magnification (400 x or higher). Ocular plates with two well-developed corneae, separated from the scutum by a narrow interval of striated cuticle. Dorsal and marginal setae numbering 20 pairs; venter with 7 pairs of ventral setae excluding those on the anal plates. Membranous cuticle of both dorsum and venter distinctly marked with striae which for the most part are parallel.

Coxae I (Fig. 251) each with two setae ventrally and a small inconspicuous supracoxal seta; II with one, III with two setae. Between coxae I and II is a large well-developed urpore and anterior to coxa III at the margin of the body, a large sclerite obviously comparable with that found in *Lassenia lasseni*, new species. In the sole specimen available the soft parts were not very well hydrolyzed and a glandlike mass of cells can be seen extending up to the inner surface of the plate. Intercoxal area devoid of setae; postcoxal area with seven pairs of ventral setae surrounding the well-defined anal sclerites which bear an additional two pairs of slender setae.

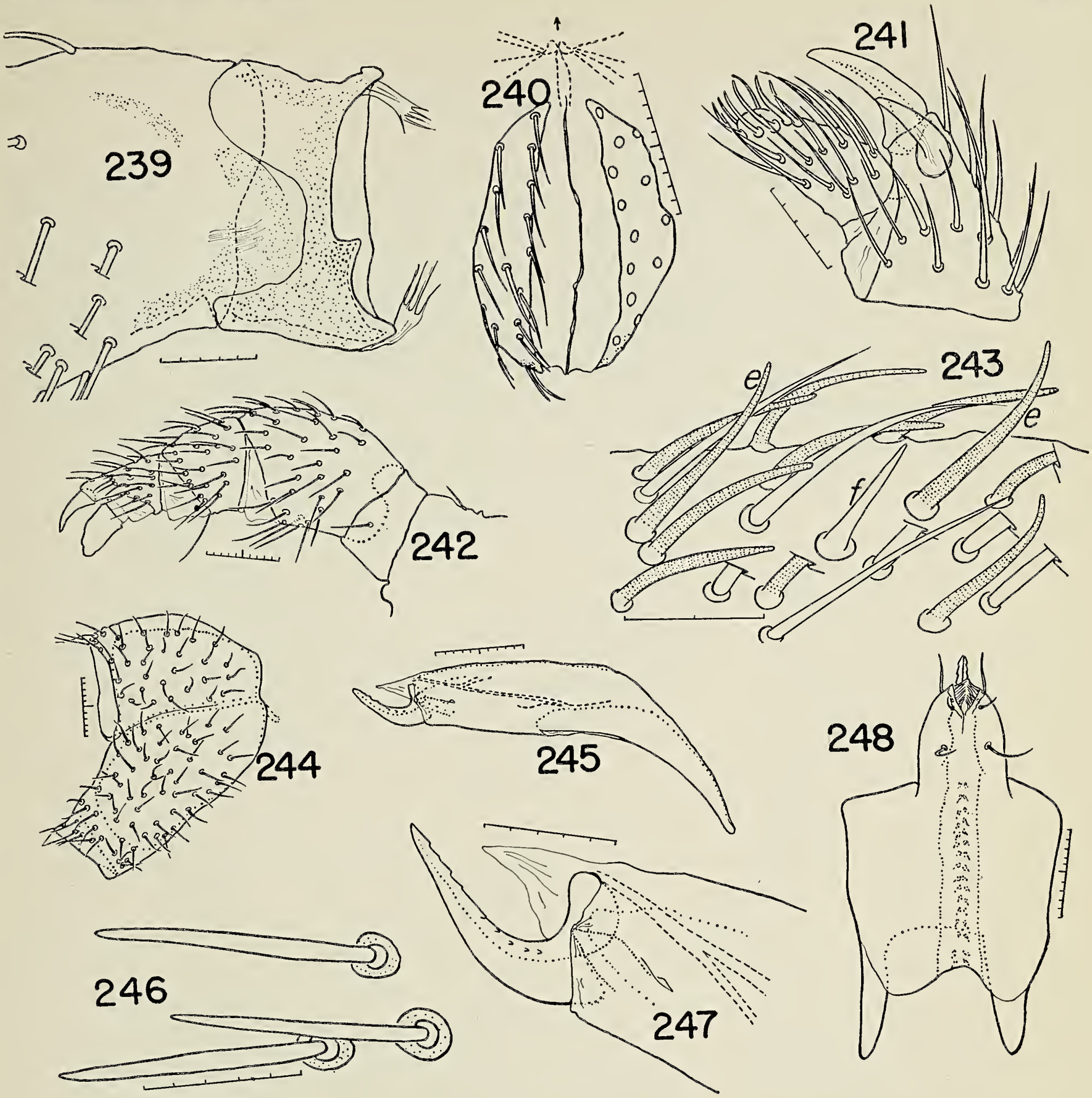
Base of gnathosoma as described for *Lassenia lasseni*. Podocephalic canals probably present but not visible because of opacity of specimen. Supracoxal setae present, structure of velum obscured by organic accretions evidently resulting from feeding activities of mite; protorostral, deutorostral and tritorostral setae present, posterorostrals absent.

Chelicerae (Fig. 261) essentially as in *Lassenia lasseni;* tarsus with two teeth dorsally (not visible in figure because of rotation of chelicera). Cuticle of chelicerae faintly and sparsely punctate, with parallel longitudinal striae dorsally. Palpi (Fig. 265) distinctly five-segmented, trochanter and femur completely separated, not partially fused as in *Lassenia lasseni*. Trochanter very short, ringlike, femur bearing only two setae, one dorsally and one anteriorly. Patella wedge-shaped, bearing a single long seta dorsally; tibia with only three very slender slightly pectinate setae in addition to the heavy terminal toothlike seta; the latter is not bifid at the tip but the microscopic structure of the hollow tip appears identical with that of the type species. Tarsus of palp with a distinctly annulate solenidion at 0.28*p*, one eupathid at 0.69*d*, and a second one terminally, otherwise with nine normal setae. The most basal of the latter is rather sharply deflexed and heavily pectinate, but it is not short and stout as in the genotype. Base of tarsus also with a pit-like structure dorsally, the exact nature of which is not known.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Chaetotaxy of legs differing in numerous specific respects from *Lassenia lasseni*. Trochanters I to III (Figs. 262–264) with a single seta each. Femora with no trace of subdivision, so that the legs have only five free segments as in the type species. Patella I and II with vestigial seta of the same form as found on tibia I (Fig. 257). Tibia I with, II without a vestigial seta; tibiae not so richly supplied with solenidia$_3$ as in the case of *Lassenia lasseni*, there being only four on tibia I. Tibia I with a solenidion$_4$ at 0.72*d*, but II and III with only the solenidia$_3$. Tarsus I with s_1 and companion setae at 0.27*d*, a smooth, elongate spikelike famulus at 0.68*pd*, a eupa-

	tr	fe	pa			ti					ta					
	n	n	s_3	v	n	s_3	s_4	v	c	n	s_1	s_2	e	f	c	n
I	1	6	2	1	5	4	1	1	1	8	1	0	2	1	2	36
II	1	6	1	1	4	2	0	0	0	9	0	1	2	1	1	29
III	1	5	1,0	0	4	1	0	0	0	8	0	0	1	0	0	24



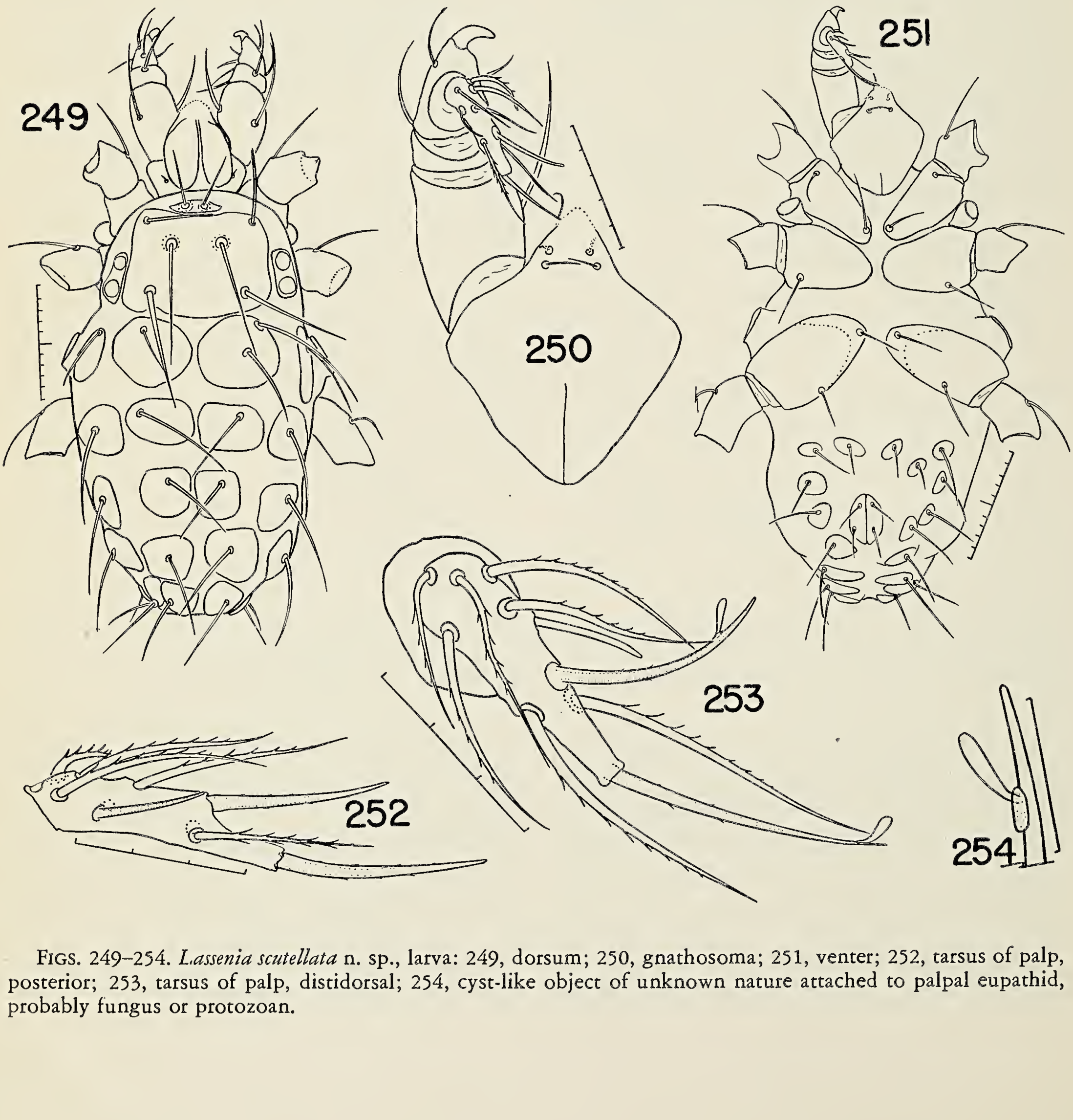
FIGS. 239–248. *Lassenia spinifera* n. sp., female: 239, trochanter and femur of palp, anterior; 240, anus; 241 tibia and tarsus of palp, anterior; 242, palp, posterior; 243, tarsus I, showing setal types; 244, coxae III and IV. 245, chelicera; 246, dorsal hysterosomal setae; 247, end of chelicera; 248, gnathosoma, ventral.

thid and companion seta at 0.71*ad* and a second eupathid at 0.92*p* (Figs. 255, 258, 260). The famulus is inserted on a somewhat vesicular alveolus, but this is not as prominent as in *L. lasseni;* moreover, the tip of the famulus tapers to a fairly sharp point and is not expanded at the tip as it is in the type species. Tarsus II with s_2 at 0.40*d*, famulus at 0.61*d* of the same form as found on tarsus I, a peripectinate eupathid and companion seta at 0.67*d* and a second eupathid at 0.94*p*. Tarsus III with a single eupathid at 0.92*p*. Most normal setae of legs bihemipectinate, the pectinations visible at magnifications of 200 x and higher; total number of normal setae on legs about 145, compared with 240–245 in *L. lasseni*. Other features of chaetotaxy as shown in the accompanying table. Three

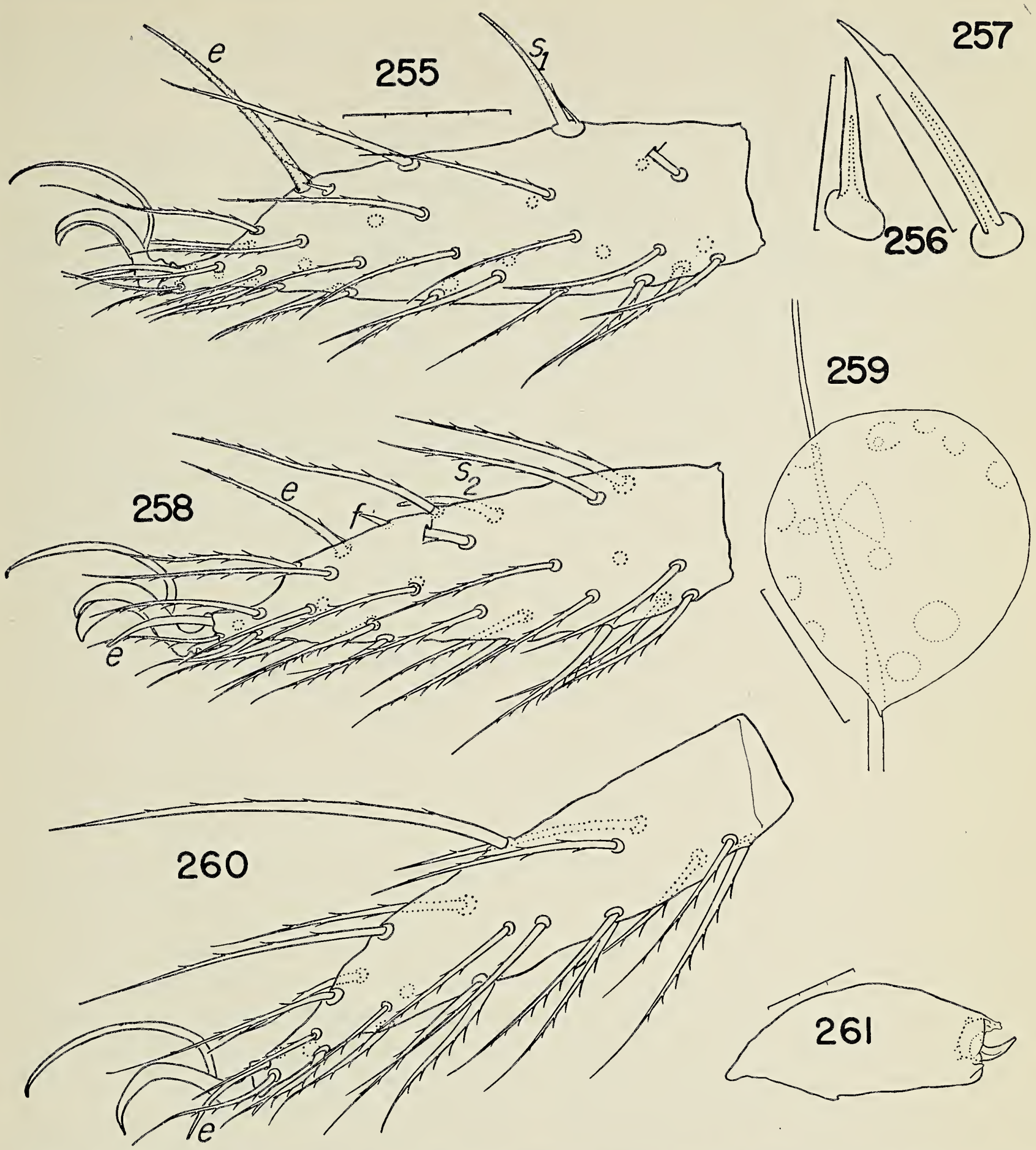
claws on all tarsi, the median claw considerably more slender and erect than the lateral claws; lateral claws with a fringe of hairs along the outer margins, median claw also appearing hirsute under oil immersion.

TYPE LOCALITY: Spencer's Butte, Eugene, Oregon (holotype larva). The type and only specimen was found in material beaten from shrubs, July 10, 1952, collected by the writer. Since *Lassenia lasseni* has larvae of the self-detaching type, it is probable that the present species has this same habit. Therefore it is impossible to say whether the larva was actually crawling on the shrubs or whether it was attached to a host insect which happened to be on the shrubs. It had obviously been feeding.

REMARKS: It is possible that this is the larva of *L. spinifera*, but since the locality records for the two are quite different, it is best not to correlate the larva and adult at this time. *L. scutellata* and *L. spinifera* are at present known only from the state of Oregon. *L. scutellata* can be readily differentiated from *L. lasseni* on the basis of the characters discussed under the remarks following the description of the type species.



FIGS. 249–254. *Lassenia scutellata* n. sp., larva: 249, dorsum; 250, gnathosoma; 251, venter; 252, tarsus of palp, posterior; 253, tarsus of palp, distidorsal; 254, cyst-like object of unknown nature attached to palpal eupathid, probably fungus or protozoan.



Figs. 255–261. *Lassenia scutellata* n. sp., larva: 255, tarsus I, posterior; 256, famulus$_1$, tarsus I; 257, vestigial seta, tibia I; 258, tarsus II, posterior; 259, organism of unknown nature attached to seta at base of femur I; 260, tarsus III; 261, chelicera.

Polydiscia Methlagl 1928

The resemblance between the larva of *Polydiscia squamata* Methlagl 1928 and that of *Lassenia scutellata* n. sp. is so close as to leave little doubt of the very close relationship between *Polydiscia* and *Lassenia*. The genus must therefore be removed to the Johnstonianidae. Thor and Willmann (1947, p. 342) placed the genus in the Trombiculinae, Radford (1950, p. 99) placed it in the Microtrombidiinae, and Baker and Wharton (1952, p. 251, *Polydisca*, *sic*) listed it with the Trombidiidae whose subfamilial relationships are unknown.

The major points of similarity to *Lassenia* are the presence of two pairs of sensilla on the scutum (not a single pair as assumed by various authors), the large setigerous sclerites covering the dorsum, the 2–1–2 setal formula of the coxae, the presence of distinct setigerous anal sclerites, and the tridactyl tarsi of the larva. There are however, certain differences such as the apparently rectangular form of the base of the gnathosoma, the simple form of the palpi, the absence of a clawlike seta on the tibia of the palp and the subdivision of the femora of the legs, (provided these were all accurately represented in the original descriptions, which is improbable).

The fact that the anterior pair of setae of the scutum were not considered sensilla undoubtedly stems from the weak development of the alveoli of these setae. Precisely the same situation is found in *Lassenia scutellata* (Fig. 249), although close study of these setae at high magnification shows that they do have somewhat more elaborately developed alveoli than do the other setae of the scutum. The anterior setae of *Lassenia lasseni* are even less sensillar in form, although there is no doubt whatever that these are the true homologs of the anterior sensilla of such forms as *Diplothrombium*.

Thor and Willmann (1947, p. 343) stated that this was "wahrscheinlich ein Trombidioseerreger." Methlagl (p. 247) stated that *Polydiscia squamata* was responsible for trombidiasis in the vicinity of Vienna, although he earlier (p. 225) indicated that he had never found it on any host. Apparently the correlation between trombidiasis and *Polydiscia* was based solely on the seasonal abundance and general appearance of the latter. But this type of correlation can lead to absurd results as Methlagl himself (p. 247) so clearly showed when, on similar evidence, he supposed *Hauptmannia longicollis* Oudemans to be the larva of *Anystis vitis* (Schrank). For the present we can only conclude that *Polydiscia squamata* has not been shown to play any role in trombidiasis of man. On the contrary, its similarity to *Lassenia scutellata* (and hence to *L. lasseni*) is good presumptive evidence that larvae of *P. squamata* are parasites of insects and not of vertebrates.

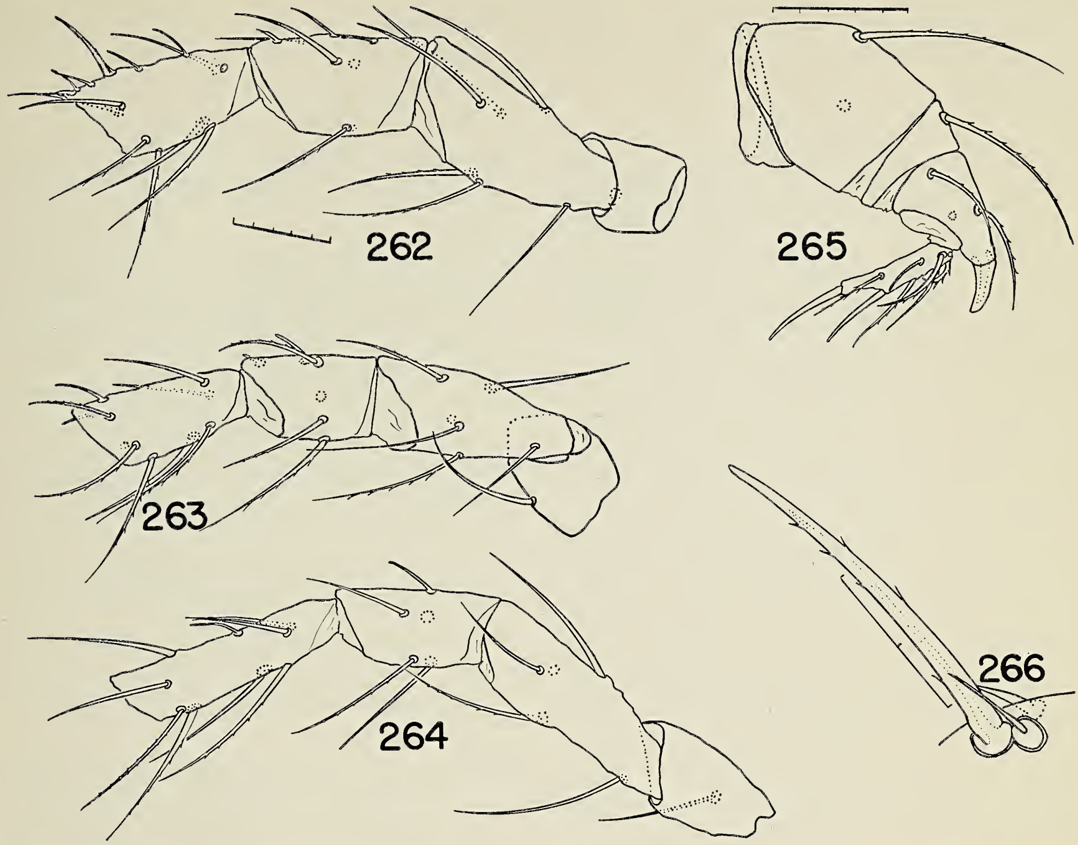
Crossothrombium Womersley 1939

This South Australian genus has been generally overlooked in recent catalogs (Thor and Willmann, 1947; Radford, 1950; Baker and Wharton, 1952). As Womersley pointed out, it is allied to *Johnstoniana*, and therefore belongs in the Johnstonianidae. However, contrary to Womersley's diagnosis, the holotype, *Crossothrombium parkhousei* Womersley 1939, appears to have two pairs of sensilla. The anterior pair, as in the case of *Lassenia*, is appreciably different from the posterior pair, but nevertheless they must be regarded as the homologs of the anterior sensilla. Womersley indicated that the eyes are absent which would be a significant point of difference between this genus and all of the others of Johnstonianidae. He also indicated that the dorsal setae arise from large "pits or circles," which are evidently the setigerous sclerites so typical of the Johnstonianidae. The tarsus of the palp was described as being "without terminal spines." If "spines" in this case means eupathidia, this would be unique in the family. This, too, requires verification. The description of both the genus and the species are too fragmentary to permit comparison with other genera of the family. One of the characters that can be seen in the figures is that there are several setigerous sclerites lying lateral to the scutum.

The species was described from a single specimen collected in South Australia, and was subsequently recorded from Victoria, Australia (Womersley 1942, p. 172).

Myrmicotrombium Womersley 1934

The original diagnosis of this genus was as follows: "Crista short, with two sensillary areas at anterior and posterior end. One eye on each side, in front of the anterior end of crista. Body as in *Microtrombidium*. Tarsi at end truncate, with one or two small, raised prom-



FIGS. 262–266. *Lassenia scutellata* n. sp., larva: 262, leg I, trochanter-tibia; 263, leg II, trochanter-tibia; 264, leg III, trochanter-tibia; 265, palp, posterior; 266, dorsal eupathid, famulus, and companion seta, tarsus I.

inences from which arise plain setae." Womersley pointed out in his remarks that the presence of two pairs of sensilla on the scutum indicated a relationship to *Diplothrombium* and also to *Johnstoniana* (= *Rohaultia*). However, a study of his figure of the scutum shows that this is in no way similar to the scutum of either *Diplothrombium* or of *Johnstoniana*. In fact it is very suggestive of the scutum of Erythraeidae such as *Balaustium*. Likewise the sharply cutoff form of the tarsus, with the distal face of the tarsus nearly vertical is not found in any Johnstonianidae known to the writer, but is found in some of the smaller Erythraeidae. Again, the setae are quite elaborately pectinate, which is also unlike the Johnstonianidae, in which the setae of the body are generally smooth and borne on elevated alveoli. The single eye is also more characteristic of certain of the Erythraeidae than the Johnstonianidae. The association of the type species with ants would also be quite unusual for the Johnstonianidae which are largely subaquatic, and are normally found only in very wet situations which would be incompatible with ant nests. In view of these considerations it is the feeling of the writer that the genus *Myrmicotrombium* does not belong in the Johnstonianidae, but rather in the Erythraeidae. A study of the chelicerae of the type species would resolve this question; unfortunately Womersley did not describe these. The type species, *Myrmicotrombium brevicristatum* Womersley 1934 is known from a single

specimen collected at Glen Osmond, South Australia. The type is in the South Australian Museum.

REFERENCES

BAKER, E. W., and G. W. WHARTON. 1952. *An Introduction to Acarology.* MacMillan Company. xiii + 465 pp.

BERLESE, ANTONIO. 1887. *Acari, Myriapoda, et Scorpiones hucusque in Italia reperta.* Fascicle 42. Padova.

——— 1912. Trombidiidae. Prospetto di genere e delle specie finora noti. *Redia* 8: 1–291.

——— 1918. Centuria quarta di Acari nuovi. *Redia* 13: 115–192.

COOREMAN, JEAN. 1952. Biologie et études faunistiques des Acariens. *Ninth Internatl. Cong. Ent., Trans.* 1: 1095–1100.

GRANDJEAN, F. 1935. Les poils et les organes sensitifs portés par les pattes et le palpe chez les Oribates. *Soc. Zool. de France, Bul.* 60(1): 6–39.

——— 1947. Étude sur les Smarisidae et quelques autres Érythroïdes (Acariens). *Arch. de Zool. Expt. et Gén. Notes et Rev.* 85(1): 1–126.

METHLAGL, A. 1928. Über die Trombidiose in den österreichischen Alpenländern. *Akad. der Wiss. Wien, Math.-Nat. Kl., Denkschr.* 101: 213–249.

MURRAY, ANDREW. 1876. Aptera. IN *Economic Entomology.* Scribner, Welford, and Armstrong. New York.

OUDEMANS, A. C. 1937. *Kritisch Historisch Overzicht der Acarologie.* Gedeelte 3, Band D: Parasitengona Oudms. V. 1909. Pp. i–xix, 1349–1998. E. J. Brill. Leiden.

RADFORD, C. D. 1950. *Systematic Check List of Mite Genera and Type Species.* 232 pages. Paris.

THOR, SIG. 1935. Übersicht und Einteilung der familie Trombidiidae, W. E. Leach 1813 in Unterfamilien. *Zool. Anz.* 109(5/6): 107–113.

THOR, S., and C. WILLMANN. 1947. Trombidiidae. IN *Das Tierreich, Lfg.* 71b: 187–541.

WHARTON, G. W. 1948. Four new Peruvian Chiggers (Acarina, Trombiculîdae), *Psyche* 55(2):87–100.

WHARTON, G. W., D. W. JENKINS, J. M. BRENNAN, H. S. FULLER, G. M. KOHLS, and C. B. PHILIP. 1951. The terminology and classification of trombiculid mites (Acarina, Trombiculidae). *Jour. Parasitol.* 37(1): 13–31.

WOMERSLEY, H. 1934. A revision of the trombid and erythraeid mites of Australia with descriptions of new genera and species. *Rec. So. Austral. Mus.* 5(2): 179–254.

——— 1939. Further notes on the Australian Trombidiidae with description of new species. *Roy. Soc. So. Austral., Trans.* 63(2): 149–166.

——— 1942. Additions to the Acarina of Australia (Trombidiidae and Calyptostomidae). *Rec. So. Austral. Mus.* 7(2): 169–181.

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——— 1920*b.* Cerotrioza (Psyllidae, Homoptera). *Hawaii. Ent. Soc., Proc.* 4 (2): 374–375.

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Figures and graphs. Copy for figures and graphs should always be drawn large enough to allow for at least one-third reduction by the engraver. Copy should consist of carefully prepared line drawings in one color only, drawn in India ink on plain white drawing paper or tracing cloth. Co-ordinate paper with lines in light blue (a color which will not show in a photograph) may be used; but co-ordinates which should appear in the finished graph must be drawn in India ink. If original figures may not be conveniently submitted with manuscript, duplicate rough sketches or photographic prints may be furnished to aid the editors in their decisions.

It is strongly urged that an indication of scale be incorporated as a part of all drawings in which magnification and size are critical considerations.

Photographs. Photographs should be chosen for clarity in portraying essential information. They should be printed for contrast, on glossy paper, and should be sent unmounted. They should be identified with serial number written in soft pencil on the back to correspond with list of captions.

Tables. Tabular matter should be kept to a minimum. Each table should be typed on a separate page, and its position indicated on the manuscript.

Captions. Readily identifiable captions for figures, graphs, photographs, and other illustrative matter should be supplied.

PROOFS

Proofs should be corrected immediately and returned *at once* to the Editor-in-Chief. All queries on proofs should be answered.

REPRINTS

Reprints or separates should be ordered when proofs are returned. Each contribution will entitle the author (or group of authors) to 50 free reprints, without covers (these 50 to be divided where more than one author is named). At the time proofs are returned, authors may order additional reprints, with or without covers, at prices indicated in a schedule accompanying proofs.

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